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BEES AND THEIR COUNTERFEITS; OR, BEES, CUCKOO-BEES, AND FLY-BEES.

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No insect is so well known to our unentomological public as the hive-bee of North-Western Europe. All the habits, peculiarities, and interesting social arrangements of this insect have been popularized in a series of works, the public appetite for which never seems satiated, and so, new volumes upon this never-failing theme, always possessing more or less merit, are continually issuing from the press; but although the natural history of our common hive-bee (*Apis mellifica*) has been thus rendered so familiar, the other members of the bee family have found but few popular historians, and less is generally known about them—except to entomologists—than about other far less interesting insect families.

Yet there are many interesting peculiarities connected with different species of the bee tribe which would amply repay the cost of a little study. I may, therefore, within the limits of the present paper, call attention to a few remarkable kinds of British and foreign bees, more especially with reference to certain extraordinary resemblances which exist between some of the honey-collecting kinds and those belonging to the parasitic or cuckoo class; which will lead to the notice of still more curious resemblances that exist between bees and certain insects belonging to a distinct order, *Diptera*. These last, though only furnished with two wings, while the bees and the whole order (*Hymenoptera*) to which they belong have four, yet bear such a striking resemblance to the bees, in company with which they are found, that an untrained observer would not, at all events on a first glance, perceive the existing difference.

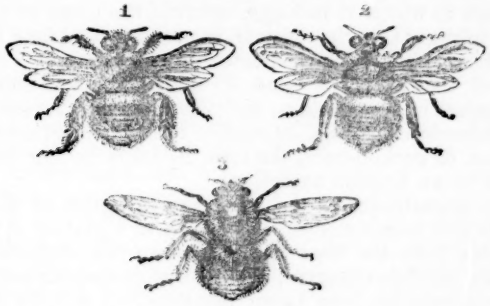
The bee family was termed by the great French naturalist, Latreille, *Mellifera* (honey gatherers), or *Anthophila* (flower lovers), both terms being characteristic of the general habits of the family. One of the most remarkable features in those kinds

of bees which live in societies, as is well known in the case of the hive-bee, is the existence of a third sex, the neuter or worker; and there are other singular peculiarities of this kind in less known species, such as the existence of two distinct kinds of females. The material of which the egg-cells are composed is very various. The comb of the hive-bee, as is well known, is formed of wax, secreted in a peculiar manner, as described in hundreds of popular works; but other species, though forming a comb almost identical in appearance, make it by the manipulation of certain substances which they reduce to a material more analogous to common manufactured paper than anything else; while others, again, make cells with sand, moistened with a glutinous secretion, which reduces it to a kind of tenacious cement. Some of these species, again, collect an inferior kind of honey, while others only collect pollen, of which they place a small mass or ball in each cell in which an egg is to be deposited, so as to form a supply of food for the grub or larva to subsist on till full grown. The exactly sufficient quantity is prepared by the instinct of the parent; and, in fact, when that is consumed, the young grub bee has no choice but to subside at once into the torpor in which his change of organization is to take place. This is a necessity, as he has no powers of locomotion, being a clumsy maggot-formed larva, which, placed at the bottom of a smooth-sided cell, would have no means of seeking food for himself. The tribes of parasitic bees which do not make cells to contain honey or pollen for the separate use of each infant bee, visit the nests of their more industrious cousins, and surreptitiously place an egg of their own in the cell containing the honey or pollen, as the case may be.

It was formerly believed that the egg of the parasitic bee was placed in the same cell with the egg of the honey-bee, and that being hatched first, the young parasite devoured all the food, leaving the infant of the honey-bee to find himself born to an empty larder, and consequently speedy starvation; but more recent observation has led to the conclusion that this is not the case, but that the parasitic bee, on entering the nest, selects cells already furnished with honey or pollen, but in which no egg has as yet been laid. While the unsuspicious female proprietors of the nest, finding an unexpected egg deposited in the cell they first visit, exhibit no sign of surprise, but pass on to the next, not seeming to be at all disturbed by the presence of the uninvited deposit; just as small birds make no attempt to exclude the egg of the cuckoo, but hatch it, and rear the young intruder along with their own offspring.

This occurs in the nests of wild bees constructed in different situations, some kinds making an excavation expressly, others

adopting the deserted work of some other insect, or taking advantage of an accidental hollow. For instance, *Anthidium manicatum*, one of our summer bees, generally uses the holes bored in willow stumps by the *Cossus ligniperda*; but a nest of this species was once found, as described by Mr. F. Smith, in the keyhole of a garden door. Some of the humble bees, on the other hand, carefully construct their own burrow. A beautiful exotic species, a large and powerful bee, has received the specific name of *Latipes*, from the singular broadening and strengthening of the front pair of feet. These broadened feet assume somewhat of the character of the front feet of the mole, or rather those of that curious insect the mole cricket. These enlarged feet, with the thick brushes of strong hairs with which they are furnished, are evidently excavating implements, and no doubt the works produced by their agency are of a very interesting kind; but entomological discovery has not at present



made us acquainted with the nest architecture of this handsome insect. A pretty little English bee, one of the solitary kinds, often makes its burrow in sheltered parts of hard gravel walks, an affair evidently of very great labour, as the female bee, who is the sole architect in this instance, frequently comes to the opening of the burrow to rest, when the male commences flying rapidly round and round his mate with great rapidity, as though to encourage her to renew the task.

I am not aware whether the nest of the little bee of the gravel walk is subject to the visits of a parasitic cousin, but among those most subject to intruders of this kind is that of the common garden humble-bee, *Bombus hortorum*. In the engraving above, this pretty bee (Fig. 1) is engraved side by side with its parasite, *Apathus barbutellus* (Fig. 2). These bees bear such a generally close resemblance to each other, that one may easily be mistaken for the other, even by the initiated, till

after a close examination, as colour, size, and general form are almost identical. There is, however, one marked difference, which is easily perceived when the trained eye has been taught where to look for it: the hind legs of the honey or pollen collector are invariably furnished with an enlarged tibia, the flattened and somewhat hollowed breadth of which serves as a reservoir, in which the pollen collected from flowers is carried to the nest. This peculiarity of formation will be observed in the engraving, Fig. 1, whilst in Fig. 2 the same part of the hind leg will be found simply rounded, and entirely without that broadened, flattened, and hollow character which distinguishes the hind leg of the honey collector. This parasite, having neither the instinct to collect food for its expected progeny, nor, in fact, the means of carrying it home even if the will existed, has been deemed by naturalists to be entirely devoid of those parental and home instincts which distinguish the recoltant or harvesting kinds. It is on that account that it has, like the genus to which it belongs, received the name of *Apathus;* apathy in regard to the providing protection or food for their young being the leading characteristic of parasites. It will be observed that the light band on the thorax, near the head, is less distinct in the *Apathus*, and also that the abdomen is not quite so profusely furred. Latreille termed these parasitic bees *Cuculinæ*, or cuckoo-bees, the term *Apathus* having been substituted by an English naturalist.

The resemblance of the third insect figure in the group above is still more curious. Although, at a glance, it so much resembles both the bees represented in the engraving as to cheat the careless observer, it will on closer examination prove itself not only far from being identical, but will be found so radically different as at once to show that it belongs to another and distinct order of insects, the *Diptera*, or two-winged order. It is, in fact, merely the general size and the colouring which deceive the eye untrained to appreciate anatomical form with accuracy. On examination, almost every part of the structure will be found to be exceedingly distinct from that of the bee: the eyes are differently placed and different in form, while their size and colour are nearly identical; the antennæ, instead of being horny and robust, like those of the bee, are delicately slender and feathered, like some kinds of moths—but these are not conspicuous appendages, and escape the attention of the ordinary spectator. The thorax, or fore part of the body, is, however, furred with orange hairs next the head, which become yellow near the abdomen, leaving the centre of the thorax black; the segments of the abdomen nearest the thorax are clothed with yellow fur; the central segments are black, and the last segments, or tail, are white—this is precisely the

colouring of both the bees (Figs. 1 and 2); but then the single pair of wings, the legs have not the enlarged or honey-bearing tibia, and even the anatomical structure of the body itself, though under the disguising fur mantle of identical colour, is of itself amply sufficient to denote that the insect belongs to another and very distinct class.

Still, the close general resemblance of this insect, *Volucella plumata*, is indisputable, and as it passes into the nest of the bee, in order to deposit its eggs (one to each) on many of the living larvæ of the bees, it might certainly, to a casual observer, pass for one of the family, while entering the bees' nest on its mission of murder to the infant bees in their cell-cradles. The egg of this parasite being deposited in the warm folds of the soft skin of the bee-larva is rapidly hatched, and it at once proceeds to its unnatural feast, slowly devouring the foster parent whose breast had warmed it into life; the bee-larva, as I have stated, being a soft, legless grub with no powers of escape. The engraving below (Fig. 4) is the larva of one of the solitary bees; very closely resembling that of the humble-bee, and indeed of the hive-bee also. The larva of the *Volucella* is represented at Fig. 5. This odious-looking creature, with its broad tail, armed with sharp spines, and its muscular body tapering to the head, and furnished with rigid serrations along each side, forms a striking contrast to the soft, helpless larva of the bee. Like all the larvæ of the *Syrphidæ*, to which the genus *Volucella* belongs, it is blind; but resting attached by the broad tail, it moves its head rapidly about as a feeler, before changing its position. The spikes at the tail may be adapted to enable it to raise itself up the smooth sides of the cell of the bee larva, in case that one infant bee should prove insufficient, and that it might require to pass on to the next cradle. But it may be as well to describe the progress of the parasitic larva on the supposition that one baby bee will prove enough for its purpose. The devoted larva of the bee, then, is gradually eaten alive by the parasite; which, with seemingly horrible instinct, spares all the actually vital parts, taking only the more fleshy portions, until the carnivorous young *Volucella* feels itself full fed and ready to undergo its torpid state of change. Then, the last remains of the wretched infant bee are greedily consumed, and the parasite passes into its sleepy chrysaline stage, taking its long *siesta* in the comfortable cradle whose infant tenant it has devoured, and from which it eventually comes boldly forth in all the pride of its winged and perfect state, walking out of the bee home as from its own proper

abode, and attracting no notice whatever from the bees, in whose nursery it has performed the odious act of eating a baby bee, and appropriating its comfortable cradle cell. The stolid unconsciousness with which the bees allow this insect vampire to pass out and escape from the scene of his horrid proceedings with impunity, has induced some naturalists to believe that the carnivorous *Volucella* owes its safety to its complete disguise in the colouring of the bee, which is supposed to be so perfect as to deceive the bees themselves into the belief that these strangers are members of their own fraternity. Mr. Westwood, quoting Messrs. Kirby and Spence, in their admirable work, in which the habits and instincts of British insects were first classified and grouped together in a pleasantly readable form, makes the following statement on the likeness of the *Volucella* to the bee:—"This similarity to the humble-bee is of eminent service to the insects which deposit their eggs in the nests of those bees, an admirable provision of Nature, since, as Messrs. Kirby and Spence observe, 'did these intruders venture themselves among humble-bees in a less kindred form, their lives would probably pay the forfeit of their presumption.'" This statement, however, though appearing so plausible, is not borne out by analogy, there being many parasites on bees which do not bear the slightest resemblance to the insects whose nests they invade. Not only are some of the *Diptera*, who deposit their eggs in the nests of bees, very unlike the bees whose homes they infest, but even the parasitic bees themselves do not always resemble the bees whose nests they appropriate. For instance, the species *Eucera longicornis* has a *broad* brownish body, without any conspicuous mark, while its parasitic relative, *Nomada sex-fasciata*, has the *narrow* body of a wasp, and, as its name implies, six conspicuous yellow bands on the abdomen, which with the intermediate black spaces, make it a very distinct-looking creature indeed.

In some of the exotic bees more especially, the distinct aspects of the harvesting bee and the parasite are very striking; they are, in fact, so much so, that the insects might be thought to belong to entirely different families. The beautiful Brazilian bee, *Euglossa dimidiata* (No. 3 in the coloured plate), has an attendant parasite as totally unlike it as it is possible to conceive of insects of the same order. *Euglossa dimidiata* is one of the most beautifully and variously coloured of the whole bee tribe. The specimen from which our representation is taken, was captured by Mr. Bates, at Para, in the Brazils; and it is found in other tropical parts of South America. Latreille described this handsome species in Schomberg's Fauna of British Guiana; but it had been previously described by Fabricius, from specimens taken at Cayenne, and named by him *Apis dimidiata*; subse-

quent divisions of the family having rendered another generic name necessary, this beautiful species was attached to the genus *Euglossa*. It forms its nest by boring tubular hollows in large reeds, and there is a specimen of a reed in the British Museum bored in this manner by this bee, or by a bee belonging to a closely allied genus.

Into such a tube the parasite bee penetrates, for the purpose of depositing its egg in the cells which have been furnished with honey or pollen by *Euglossa dimidiata*.

In this case, in order to support the theory of Messrs. Kirby and Spence, it would be more than usually necessary that the intruder should be furnished with a very complete disguise, as he must, in such a narrow tubular home, necessarily come to very close quarters with the master of the house. Yet, on the contrary, the whole aspect of the parasite of *Euglossa dimidiata* is not only extremely different, but its appearance is of that striking character calculated to excite immediate attention. Instead of being soft and furry after the fashion of the humble-bee tribe and their allies, he is entirely hard, smooth, and glittering—the entire body, thorax and abdomen, and also the legs, being of a light vivid metallic green like that of our rose-beetle. It might be urged, on the other hand, that although not provided with a security in the form of a disguise, a defence of another kind has been substituted, in the suit of impenetrable plate-armour, of magnificent green bronze, in which this insect is incased. But I feel convinced that it is entirely futile to attempt to explain the nature of providential arrangement, and point out the secret purposes for which either apparent analogies or discrepancies were devised. The best explanations offered, indeed, are too full of contradictions to be for a moment seriously accepted as revelations of intended purpose. As a ready example of the contradictions to which such speculations must be liable, I may mention here, that although the parasitic bee, which infests the nests of *Euglossa dimidiata*, is entirely unlike the harvesting-bee, whose home he invades, yet the doubly-unfortunate *Euglossa* has a second enemy, in the form of a gigantic diptera, whose similarity to the bee is most curious. This enormous fly-bee, *Asilus fasciatus*, has, it is true, only two wings, but those being of deep brown to half their length, and transparent for the remainder, bear an extraordinary general resemblance to those of the bee; while the colouring of this handsome insect being nearly identical with those of the bee, and the size and shape of the markings being almost identical, the general resemblance becomes very remarkable; hence the conspicuous appearance of one enemy is rendered utterly useless as a defence, while the seemingly perfect disguise of another apparently favours his fatal entrance to the nest. There is

another instance of a likeness so very extraordinary between a large exotic bee and its parasitic diptera, that I have represented them in the engraving below, in order to allow of careful comparison (Figs. 6 and 7).

The handsome bee figured above (Fig. 4, and No. 2 in the coloured plate), is *Xylocopa nigrita* (the female); it is a native of Sierra Leone, and is remarkable for the full deep velvety black of the greater part of the body, while the sides of the abdomen are conspicuously fringed, and partly

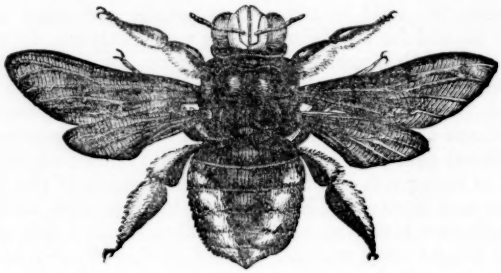


Fig. 6.

Fig. 7.

covered, with milk-white furry hairs; the effect of which call to mind the appearance of an aged negro, of the same part of the African coast, whose woolly hair has become white with age. The legs, also, are thickly fringed on one side with a similar white fur, and the "face" is white, with large, brown eyes. The wings are nearly opaque, and of deep, dull purple, with a metallic gloss, bronzy-red towards the extremities. The Diptera, or two-winged counterpart of this insect (Fig. 5), has all the characteristic contrasts of black and white, similarly dis-

posed, even to the white face and brown eyes; while the opaque, iridescent wings are precisely similar in tone and colour. The somewhat longer legs, the single pair of wings, and the different structure of the antennæ, at once prove to the entomologist that these two insects are not only not the same, but that they belong even to different "orders." They are, however, in all probability, found together, like the other bees and diptera which so strongly resemble each other—the larva of the diptera, no doubt, preying upon the larva of the bee. In proof of this hypothesis, it may be stated that both specimens were brought to England from the west coast of Africa, the bee, from Sierra Leone, the bee-fly from Port Natal, and probably both will eventually be found in the same district. The last, the bee-fly, is at present an entomological novelty, and has not yet been named. The bee exhibits, in an unusual degree, a peculiarity common to many of the family, namely, a marked difference in the general aspect of the two sexes. The individual engraved above is the female bee, the male being of a light tawny brown colour, and having a much longer body, a characteristic which generally distinguishes the female rather than the male. The two sexes of this remarkable insect are both figured in the coloured plate, No. 1 being the male, and No. 2 the female. It would be interesting to know, whether in the bee-fly, which bears so extraordinary a resemblance to this fine bee, an equal disparity of appearance exists between the two sexes; but, as we have at present only a solitary specimen of this insect, that is a point which cannot be decided; but other specimens will, doubtless, be captured, which may may enable us to solve this interesting entomological problem.

The other exotic bees figured in the coloured plate are, the pretty little *Euglossa cordata* (No. 5), a native of the Brazils; *Anthophora elegans* (No. 6); and *Crocisa picta* (No. 7), are also from South America.

In concluding my remarks on curious resemblances between "bees" and various kinds of two-winged "flies," I may mention a curious instance of a resemblance between a dipterous insect and one of the wasp tribe (*Vespidæ*). *Eumenes esuriens*, a small Indian wasp, found in Bengal, has its counterpart (the resemblance being truly extraordinary) in *Cesia eumenoides*, the specific name of which has been conferred upon it in consequence of this singular resemblance. I ought also to mention, as a case in point not the least singular, that a British dipterous insect of the *Syrphus* tribe, belonging to the genus *Eristalis*, is so like the common hive-bee, that it would, at a glance, deceive any observer untrained as an entomologist.

THE SHELL OF THE CUTTLE FISH.

It is not generally known that the internal shell of the cuttle fish (*Sepia officinalis*), so commonly found by the sea-shore, and likewise having its place among the miscellaneous items of the chemist's shop, affords one of the most beautiful objects for microscopic examination by polarized light. All that is required is to scrape a little of the soft part of the shell with a penknife, taking care not to reduce it to too fine a powder, and then mount it in Canada balsam. The slide is thus easily prepared, but to view it requires some little nicety. If exhibited without a selenite stage, the polarizer and analyzer should be so adjusted as transmit their least amount of light. When they are in this position the cuttle shell slide may be placed on the stage, and there will be seen a number of irregular shaped masses of a dull golden hue, variegated with numerous points of a brighter aspect, and likewise many more or less oblong fragments, glowing with rich purples, crimsons, yellows, emerald-greens, and shades of golden-brown. The colours or tints are arranged in numerous horizontal bands which, under an inch or two-third object-glass, show symptoms of crystallization in the shape of thousands of minute needles, an aspect that is strengthened if a higher power, such as a quarter or a fifth, is employed. Revolving the analyzing prism produces no good effects, nor does a similar process with the polarizer, the object presenting no beauty except in the one position we have described. While the prisms are in such relative positions as to transmit little or no light, the selenite stage may be introduced beneath the slide, and the colours will appear somewhat more brilliant, but pretty much the same. Revolving the analyzer still exhibits only one good view, namely, that with the dark ground, on which the fragments glisten like jewels upon black velvet. But if the polarizer is made to take a quarter turn, and the selenite is of the right thickness, a revolution of the analyzer will then exhibit two new effects, one exhibiting brilliant colours on a rich sky-blue ground, and the other on a ground of an amber tint. The blue one is exceedingly fine. A thin slice of mica, about the thickness of writing paper, placed under the slide and on the selenite, affords further changes of extreme richness and beauty, the grounds assuming, as the analyzer revolves, crimson, violet, and green hues, with corresponding alterations in the colours of the particles of the shell.

If the experimenter is successful in adjusting the prisms, and employing the right thickness of selinite or mica, this object is quite equal in splendour to the most esteemed crystals, such as

salicine or asparagin; but greater care is required for the cuttle shell than for them, and even an experienced microscopist may not immediately hit upon the right way. Perhaps no polariscope slide is better adapted to assist the artist-designer in devising patterns for shawls, carpets, and other ornamental goods, and the effect may be varied not only by the methods we have indicated, but also by the degree of fineness of the powder employed, and by determining, as we shall presently explain, the proportion which the amorphous dull golden particles bear to the most brilliant and crystalline portions of the display. But to make this intelligible we must, at all risks of offending very learned readers, say a few words on the structure of the cuttle shell, and the mode of examining it.

The first step is to cut a little block of the soft brittle substance of which what may be called the inside of the shell is composed. If such a block is viewed in vertical section as an opaque object, it will appear to consist of a great many tiers of columns of a white glittering semi-transparent substance, about one-fortieth of an inch high, and between each tier of the tiny pillars a flooring of somewhat similar material will be seen to run. Thus the first idea of construction would be that of dozens of floors supported by millions of columns, and many sections may be made and viewed in various directions without the real principle of the fabric being found out. A horizontal view, when one floor has been cut away, may perhaps disclose the secret; but the apparent columns are so brittle, that enough of them may not remain after the knife has passed through them to show the true form. By beginning at the back of the shell the chance of success is greater. First, a rough brittle layer of carbonate of lime is removed, then comes a transparent glassy-looking substance, and behind this the pillars begin, and a portion of the flooring may be taken away without materially disturbing the order in which they stood. If this does not readily yield a good horizontal section, a cube of the shell may be saturated with the colourless varnish used in photography, and when this is dry the brittle part will be strengthened sufficiently to bear rougher usage without harm. However it be accomplished, if the horizontal slide is well made, it at once becomes obvious that the columnar appearance was an optical mistake, and that instead of the floors resting upon thousands of separate pillars, they are supported by the sheet of carbonate of lime, corrugated just as a sheet of paper would be by folding it alternately backwards and forwards across a square-edged ruler. The chemical nature of the several parts may be readily ascertained by acetic acid. If a few minute fragments from different portions are placed in a drop of dilute acid, covered up with thin glass, and placed under the

microscope, the pillars or fragments of the corrugated sheet dissolve first; while the portions of the floors do not change their form, for although much carbonate of lime is removed, the animal membrane remains. The back of the shell dissolves quickly, and the glassy-looking film behind it is converted in a few minutes into a tough transparent material like gelatine paper.

Our polariscope object was composed of the floors, which furnished the amorphous fragments of dull speckled golden hue, while the corrugated supports supplied the portions that glowed with the rainbow lights. If mere splendour is required, the particles of the flooring should be rejected, and pieces of the corrugations mounted alone, taking care not to spoil the effect by breaking them up too small.

It is interesting to find the vital and chemical processes by which the cuttle shell is formed, combining to produce upon the principle of corrugation that strength associated with lightness, which man, in his recent inventions, seeks to obtain in precisely the same way. Hundreds of similar illustrations might be given, of reason obtaining by slow degrees, and manifold experiments, to methods of construction which abound in the organic world. Sometimes the human contrivance is assuredly an imitation, but oftener it is reached by an original method, and when this is the case it is impossible not to be struck with the evidence thus afforded of the unity of plan in creation, as displayed in the intimate correspondence, or relation, that exists between the tendencies of human thought and the processes, consciously or unconsciously, carried on in the lower spheres of material existence, or of subordinate animated being.

ALUMINIUM.

BY J. W. M'GAULEY.

THERE is no subject connected with chemistry of more importance than that of the metals: nor is it an exaggeration to assert, that they have been the principal agents in civilization. We are chiefly indebted for the latter, however, not to those which are costly and rare, but to that which, by a beneficent dispensation of Providence, is the most common of them all: since iron has been of far more value to mankind than gold.

The ancients were acquainted with but few metals. In very remote antiquity, metallurgical knowledge was almost confined to copper and tin, which were more easily reduced than iron. And, as it was soon discovered that some of their alloys were

extremely hard, they were employed in the manufacture of axes, swords, and other weapons, after still ruder materials were discarded: hence, warlike and domestic instruments of bronze, are found among the oldest relics of distant ages. But iron at length obtained its fitting place among the substances useful to man; and its abundance, its extreme softness when softness is required, its extreme hardness when that quality is desirable, its elasticity, its malleability, ductility, tenacity, and other admirable qualities, have caused it to acquire and maintain the very first rank among the useful metals. Gold and silver, it is true, have been known from the earliest times; but their use, like their supply, has always been limited; and much of the value attached to them is due to their scarcity. Lead, also, and zinc—at least as an ore, and as one of the ingredients of brass—were familiar to the ancients. But we have now enumerated all the metals with which they were acquainted; and, in truth, all that to any great extent have yet been utilized.

We are, on this occasion, specially to treat of a metal which has been a source of great expectations: and, fortunately, there is no reason to consider that these have been disappointed; their complete realization is only deferred, and most probably for but a short period: and one of our objects in directing attention to it, is to excite a more general inquiry regarding it. The establishment of aluminium among the most important of the metals, is a mere question of the cheapness of its production: and as, up to this time at least, it is most conveniently obtained by means of sodium, investigations regarding it, resolve themselves into a determination of the most economical method of obtaining that metal. On this point, our knowledge has already progressed considerably, and hence the price of aluminium has greatly fallen. Not long ago it was £3 per ounce, it is now only about 5*s.*: and it will, no doubt, be far less, if we are to judge by the extraordinary improvements always made, after a time, in chemical processes. How much lower in price are the most useful substances at present than they were a very few years ago, because the methods of manufacturing them have been simplified. But, even at its present cost which, by *weight*, is the same as that of silver, aluminium is really only one-fourth as dear, *bulk* for bulk: and this, after all, is the test, since bulk for bulk, it is as strong, and even stronger than silver. When there is question, however, of its application to domestic purposes, we must compare its cost with that of pewter or copper: it would chiefly supersede these, which, among other disadvantages, are productive of very noxious compounds, particularly the copper.

The qualities of the precious metals are quite distinct from those of the more common: nor have the two classes hitherto

been connected by any intermediate metal—that is, by one possessing the most characteristic properties of each; but it is hoped that aluminium may supply such a connection. Like the precious metals, it is brilliant, and little alterable by chemical agents—scarcely at all, under ordinary circumstances. Like the common metals, it is very abundant, constituting one-fourth, by weight, of the most widely diffused bodies. It is malleable, ductile, hard, and tenacious; its compounds are harmless—which is true of scarcely any other metal but iron: and, unlike both the precious and the common metals, it has the advantage of being extremely light. It is admirably suited to all ordinary purposes: and is one of the best that can be used for those which are artistic and ornamental. M. Christofle, in 1858, exhibited before the Academy of Sciences a group in aluminium, which had been cast and chiseled: and which afforded an excellent example of its capabilities, though it was its first application to such a purpose.

Davy, soon after he had discovered the metallic bases of the alkaline earths, in 1807, proved the existence of aluminium, from potassa being produced when the vapour of potassium was brought in contact with alumina heated to whiteness; and he even obtained it, in combination with potassium. It was procured by Wöhler, in 1827, as a grey powder; and in 1845 in the form of very minute globules: but probably from being more or less impure, it did not exhibit the same properties as when in a massive state. On account of the high price of potassium, at the time he made his experiments, and other obstacles, he did not obtain it in particles larger than a pin's head: and he succeeded in uniting these, only by great chance, and after many trials: since the presence of minute quantities of other substances, or a slight coating of oxide, would prevent their coalescing. M. Degousse, a gold-beater of Paris, succeeded in preparing it in the form of very thin plates: and he found that, in beating them out, it was necessary to re-heat them more frequently than other metals in similar circumstances. M. Deville has been the most successful of all those who have made experiments upon it. We shall first describe the most convenient methods of obtaining aluminium, particularly on the small scale: and shall then examine its properties and combinations—omitting nothing of any importance, that has yet been discovered regarding it. As to the mode of procuring it on the large scale, it does not concern the object we have in view: but it may, in a great degree, be conceived from what we shall say.

When we attempt to get aluminium directly from alumina, with potassium, or sodium, we do not succeed: most likely from its being necessary that the potash, or soda, which would then

be formed, should unite with some of the undecomposed oxide —which does not seem to occur, though aluminates of the alkalies are very easily made. But M. Chapelle, in 1854, procured it by introducing pulverized clay, sea salt, and powdered charcoal, into a common crucible, and heating the mixture with coke, though not to whiteness, in a reverberatory furnace. When the crucible was cold, a considerable quantity of minute globules of aluminium were found at the bottom. It must be admitted that the simplicity of this method, if it could be rendered economical, would make it deserving of preference: and it is not improbable that it may hereafter be so improved as to supersede all others. To obtain aluminium through the medium of a troublesome metal, seems at best a clumsy process. It is, however, the most successful that has been yet devised; and we are indebted for it, in its present improved state, to the ingenuity and researches of Deville, whose method is a modification of Wöhler's. He received from the present Emperor Napoleon the funds necessary for making his experiments on a large scale, and in a satisfactory manner: and he first published an account of them in 1854.

It occurred to him that, on account of its smaller equivalent, and the commercial value of its salts, sodium would be better for the purpose of obtaining aluminium than potassium, which had been employed by Wöhler. Other advantages, besides, were found to follow from its adoption: the manufacture of sodium is easier, and even safer, than that of potassium: and when the process goes on well, those carbon compounds which are so annoying with potassium, do not make their appearance: nor is its reduction accompanied by the explosive substances—probably compounds of hydrogen—which are so dangerous in the reduction of potassium. Moreover, the use of potassium in obtaining aluminium is not very safe, it inflames so easily, and often produces such violent explosions: while sodium can be employed without fear, since it may be raised in the atmosphere to a higher temperature than its point of fusion—indeed, we have reason to believe that it is inflammable only in a state of vapour, though still at a temperature below its boiling point; and, if it is kept very carefully from water, there will be little likelihood of its taking fire.

To get pure aluminium by Deville's method, we require pure alumina, pure chloride of aluminium, and metallic sodium: for any impurities present in these will be concentrated in the aluminium, and affect its properties very much: nor, if once combined with it, can they ever be entirely removed. We shall first, therefore, describe how these are to be had.

To obtain *pure alumina*.—Eight and a half parts, by weight, of the sulphate of alumina of commerce, for every required

part, by weight, of pure alumina, are dissolved in an equal weight of water, and precipitated by a concentrated and boiling solution of acetate of lead in slight excess; and the smallest possible quantity of tartaric acid, is added to the liquor which is separated by decantation, to prevent the precipitation of alumina. The acetate of alumina is then supersaturated with ammonia, and the ammoniacal solution, after being treated with hydrosulphuret of ammonia, in a closed vessel, is placed in a stove having a temperature of from 122° to 140° Fahr.: this determines the precipitation of the sulphurets of iron and lead, which are removed, first by decantation, and then by filtering —but without washing the filters. The clear and slightly yellow liquor, which consists of acetate and tartrate of alumina combined with ammonia, and some hydrosulphuret of ammonia, is rapidly evaporated and carbonized in an earthen crucible. The residual mixture of alumina and carbon is made into a paste with oil, and strongly calcined to expel the sulphur—due to a little sulphuric acid which remains in the alumina, the whole of it not having been separated by the acetate of lead.

To obtain *pure chloride* of *aluminium*.—Some of the mixture of alumina and carbon, just mentioned, is introduced into a porcelain tube that has been fitted with another tube, and is heated to redness in a current of dry chlorine. Chloride of aluminium sublimes, and is removed from the tubes in compact masses, which are composed of very beautiful crystals, that are either colourless or slightly tinged with yellow. If, however, from the impurity of the materials, this chloride is not found to be quite pure, it is heated with nails or iron-turnings, in an earthen or cast-iron vessel, which, when the permanent gases have passed off, is closed: after which, the heat being continued, a slight pressure results, that causes the chloride of aluminium to melt and come in contact with the iron. This changes the volatile *per*chloride of that metal into the *proto*chloride, which is comparatively fixed: and the chloride of aluminium, completely purified, crystallizes in the vessel itself in large transparent and colourless prisms: and a distillation in hydrogen finishes the process.

To obtain the *sodium*.—Its preparation is founded on the reaction of an alkaline carbonate on carbon; and carbonate of soda, wood charcoal, and carbonate of lime are required in the following proportions—

Carbonate of soda	717
Wood charcoal.....	175
Chalk	108
	1000

The carbonate of soda should be obtained from crystals dried and pulverized fine: the carbon and chalk should also be reduced to powder; and the whole, as soon as possible after having been mixed, should be made into a paste with very dry oil, and then calcined at a red heat in an iron mercury-bottle, that it may occupy a small space—and thus a larger quantity of potassium be obtained by the subsequent process. The calcined mass is subjected to a high heat in an iron mercury-bottle, which is not so rapidly destroyed as might be expected, and ought to last for three or four operations; it is kept comparatively cool by the resulting oxide of carbon, and by the sodium assuming an æriform state, and the heat required is not near so great as might be supposed. An iron tube leads from the bottle which is inside the furnace, to a receiver, which is outside, and has an aperture for the escape of the gases. The carbonic oxide formed from the chalk, assists in carrying the vapour of sodium rapidly into the receiver, and thus prevents it from decomposing any of the gas by which it is necessarily surrounded—an effect that would be facilitated by its finely divided state as vapour; the receiver also is thus kept hot enough to unite the metallic globules, without a wasteful after process. One-seventh of the weight of the mixture which has been used, or one-fourth of the weight of the carbonate of soda, should be obtained in sodium. If the mixture employed has been such as to melt, it will have prevented a free disengagement of the gases.

To obtain the *aluminium*.—From 3000 to 5000 grain of chloride of aluminium are placed in a tube of glass or porcelain, about one and a half inches interior diameter, and are insulated by two plugs of asbestos. Hydrogen, purified and dried, by being transmitted through sulphuric acid and chloride of calcium, is sent through the tube: and, while it is passing, the chloride of aluminium is gently heated by a few coals, to drive away any hydrochloric acid which may have been formed by the action of the air on the chloride, and also the chlorides of sulphur and silicium which are invariably present in small quantities. Sodium, previously crushed between two pieces of dry filtering paper, and placed in a boat, is then introduced into one end of the tube while it is still full of hydrogen, and is melted; the chloride is at the same time heated so as to make it rise in vapour, that it may come in contact with the sodium, and be decomposed; and when the sodium has disappeared, and the chloride of sodium that has been formed is saturated with chloride of aluminium, the process is complete. An incandescence which occurs is easily regulated. The boat, being taken from the tube, the mixed chlorides, in which the globules of aluminium are suspended, are removed, by dissolving in

XUM

water: and the globules, covered up in a porcelain crucible either with mixed chlorides of aluminium and sodium, or with common salt, are fused together by a strong heat.

This process answers still better on the large scale; but, instead of the porcelain tube and boat, two cast-iron cylinders connected by a smaller tube of iron are employed. The anterior cylinder contains the chloride of aluminium; the posterior, sodium in a tray; and the iron tube, kept at a temperature of from 400° to 500° Fahr, scraps of iron to separate any of that metal which may rise with the vapour of chloride of aluminium, by changing it from volatile *per* to fixed *proto*-chloride.

Œrsted, who was the first to form chloride of aluminium, is said to have obtained that metal, by heating the chloride with an amalgam of potassium, rich in the latter, and driving off the mercury from the resulting amalgam of aluminium, by heat.

Aluminium may also be procured from *Cryolite*, a mineral which exists abundantly in Greenland, though it is found only in small quantities elsewhere. It is a double fluoride of aluminium and sodium: and may be produced artificially, by adding hydrofluoric acid in excess to calcined aluminium and carbonate of soda, so as to produce

Fluorine	54·5
Aluminium	13·0
Sodium	32·5
	100·0

then evaporating, and fusing the result. Both the native and factitious cryolite give aluminium with sodium, and with the galvanic current. The latter, with a mere *mixture* of aluminium and fluoride of sodium, would afford only sodium and fluorine. It occurred to Rose that, on account of the deliquescence and volatility of the chlorides of the alkaline metals, and the necessity, when they are employed, of preventing any access of atmospheric air, it would be better, in the reduction of aluminium, to use a fluoride of that metal combined with an alkaline fluoride; and he proposed to use cryolite, but was deterred by its scarcity at that period. To obtain aluminum in this way, finely powdered cryolite and sodium are placed alternately in layers, in cast-iron crucibles, the whole being covered with a good thickness of chloride of potassium as a flux. The crucible is then carefully closed with a porcelain cover, and raised to a red heat for half an hour. After which, the calcined matter having been softened with water, it is broken down in a porcelain mortar. The larger globules of aluminium are easily

separated mechanically; the smaller, by dissolving away the mass in which they are imbedded, with nitric acid, without heat. The globules are fused, as before, under the mixed chlorides, or common salt; without this, the slight coating of oxide on their surface would prevent their union. When common salt alone is used, a higher temperature is required. The aluminium obtained from cryolite almost always contains silicium, and even iron: and the product is not abundant, since 10 of cryolite and 4 of sodium give only 0·5 of aluminium. Rose attempted also to procure aluminium, by placing the mixed chloride of aluminium and sodium, in alternate layers with sodium; but the results were not satisfactory.

Bunsen proved, in 1854, that aluminium may be obtained by means of the galvanic battery, in the same way as magnesium. But, as chloride of aluminium cannot be used for the purpose, since, instead of fusing, it volatilizes, he employed the double chloride of aluminium and sodium, which is not volatile except at a higher temperature than the fusing point of aluminium. The apparatus also must be somewhat different from that used in reducing magnesium. For the electrolysis, two parts chloride of aluminium, and one part common salt dried and pulverized, are mixed in a porcelain capsule, and heated to about 390° Fahr.; after a while the mixture becomes a clear liquid.

The apparatus, in which the decomposition is to be effected, consists of a glazed porcelain crucible, placed in another of earth; the latter is closed with a cover having one opening, at the side, sufficient to allow a thick plate of platina to pass down through it for the negative electrode, and another in the centre, to admit a porous vessel, which has been well dried, and in which is placed the positive electrode—a piece of gas-retort graphite. Both the crucible and the porous vessel—which is of less depth, are filled to the same height with the melted double chloride: and the latter is kept hot, but not sufficiently so to melt the aluminium. A battery of about five circles is connected with the electrodes; and the aluminium and common salt, which will be deposited on the platina plate, is occasionally removed. Chlorine and a little chloride of aluminium will separate in the porous vessel, unless prevented by a small quantity of common salt, thrown into it now and then, in a dry pulverulent state. The mixture which has been detached from the platina plate, is melted in a porcelain crucible protected by another of earth; the fused mass is dissolved in water, and the particles of metal obtained from it, are melted several times under the double chloride of aluminium and sodium.

The battery does not give so pure a metal as the sodium process, which removes the silicium, sulphur,—and even the iron,

from the materials; but these impurities are found only in the first portions detached from the platina plate. On account of the small atomic weight of aluminium, compared with that of zinc, the mode of obtaining it by electrolysis is too expensive for ordinary purposes.

The *properties* of aluminium are very remarkable, and many of them are highly important. It is white, with a bluish tinge, but when its surface is quite clean, its appearance differs very little from that of silver; its splendour is not indeed quite so great, but lasts much longer. A very white and beautiful, though not a polished surface, may be easily given to it, by plunging it for an instant into a very dilute solution of caustic soda, washing it with water, and then digesting it in strong nitric acid. This removes everything that can soil it, except silicium if in considerable proportion. Aluminium takes a fine polish, and preserves it for an indefinite period; but to render it as brilliant as possible, a mixture of stearic acid and spirits of turpentine must be used, between the rotten stone and finishing powder; and the polishing process must end with spirits of turpentine. Its characteristic blue tint is more perceptible when the surface is polished than when it is dull. It often assumes a crystalline form, if cooled slowly. When pure, it has not any taste. If it contains a large portion of silicium, it has a slight smell of siliciuretted hydrogen; otherwise it is inodorous. Hot or cold, it is as malleable as gold or silver, and is reducible to as thin leaves. It differs from all other malleable metals, by being deprived of malleability if alloyed with any other metal. It is so ductile, that it may be drawn into an extremely fine wire: but its ductility also is affected by admixture. Its tenacity, and elasticity, are nearly the same as those of silver. When cast, it is as hard as pure silver; but when hammered, it is as hard as soft iron. It seems to be one of the best known conductors of electricity; its conducting power is eight times greater than that of iron: but this also depends very much on its purity. Since metals generally conduct heat in about the same proportion as electricity, it is, as we might expect, an excellent conductor of heat—probably a better one than silver. It is slightly magnetic. When pure, and in the form of a bar, it is remarkably sonorous: and if suspended by a thread, it emits a sound like that of a glass bell: but in other forms, its tones have not been found agreeable. Its specific gravity is only 2·56, and when hammered 2·67; no other metal of small density has been found malleable, tenacious, sonorous, and a good conductor. Iron is nearly three times as heavy, copper nearly four times, lead nearly five times, and platina nearly nine times. Even though prepared to find it very light, we are astonished on handling it. This property

causes it to answer admirably for spectacles, the beams of delicate balances, sextants, etc. It is well adapted for small chemical weights: the increased size of which causes them to be more easily moved, and less easily lost. M. Dumas exhibited to the Academy of Sciences a helmet of aluminium, which was very brilliant, had been gilt by the battery, and was joined by solder with great solidity; it weighed less than twenty-five ounces avoirdupois. If of brass, it had weighed nearly sixty ounces, and would not have been so strong. Aluminium cannot easily be adulterated, because even small quantities of other metals deprive it of malleability and ductility. Nor can it be imitated by other metals, for their weight would betray them. All the other less oxidizable metals are heavy, and have a much greater atomic weight. Its point of fusion is somewhat higher than that of zinc, and lower than that of silver. It flows readily into moulds of metal, or sand; any flux would be injurious to it, but it requires none. It fuses very slowly, for its specific heat is very high, and therefore its latent heat is considerable—it exceeds all ordinary metals in this respect. It therefore keeps warm for a long time, which may be found a useful property. If pure, it is scarcely affected even by the oxyhydrogen blowpipe, but the presence of oxidizable metals facilitates its oxidation. Though silicium has itself little tendency to unite with oxygen, its presence causes aluminium to burn with great splendour, silicate of aluminium being produced. In the form of a thin plate, it burns with great brilliancy, in the flame of a spirit-lamp; but the light it emits in combustion becomes intense, when the flame is urged with a jet of oxygen. If pure, or nearly so, it is not tarnished by air or moisture; it may be fused in the atmosphere without oxidation, and may even be raised in a cupel to a temperature higher than is required for the assay of gold, without being altered. Water, either as a liquid or vapour, has no effect upon it, though heated to near its melting-point: and at a white heat, produces only a slight oxidation. But if chlorine is present, it acts upon it like a hydracid, hydrogen being disengaged, and a soluble compound formed. If, however, it is in the form of a thin plate, it will cause a small quantity of hydrogen to be evolved, when it is placed in boiling water.

Nitric acid, whether concentrated or dilute, has no effect upon it, at ordinary temperatures; it is slowly dissolved in boiling nitric acid, but the solution ceases if the acid is allowed to cool. Sulphuric acid, whether concentrated or dilute, does not act upon it; nor is it, like zinc, rendered soluble in the acid by contact with another metal. But it is dissolved by hydrochloric acid, whether concentrated or dilute; slowly if pure, but with great rapidity if otherwise. It is the acid, and not the water

in which the acid is dissolved, that is decomposed; since hydrochloric acid gas acts upon it at a very low temperature, forming an anhydrous and very volatile chloride; and the more concentrated the acid, the more energetic its effect. Whenever aluminium is tarnished with water, on testing with nitrate of silver, it will be found that chlorine is present. If a wire of aluminium is plunged for an instant into dilute hydrochloric acid, a considerable amount of it will be changed into a white substance, after it has been withdrawn from the acid, and without any absorption of oxygen. Acetic acid, diluted to the strength of strong vinegar, has little or no effect upon it; but it is important to bear in mind that a mixture of vinegar and salt dissolved in water, acts upon it—in accordance with a well-known chemical law, according to which the acetic acid displaces some of the chlorine, and this forms hydrochloric acid, its proper solvent; but the action in such a case is very slow, particularly if the metal is pure. Tin would be more affected in the same circumstances, and would impart a bad taste, which does not occur with aluminium. It is scarcely acted on by tartaric acid—a valuable property, if it is used in connexion with wines. Its combinations with the feeble acids are harmless, which is not the case with most of the other metals; and they are decomposed at a low temperature. Solutions of potash and soda act upon aluminium very energetically, forming aluminates of the alkalies, with evolution of hydrogen. But monohydrates of the alkalies, even at a red heat, affect it no further than to remove from its surface any silicium that may be present upon it. Ammonia acts upon it slightly, but only in presence of water—which is decomposed, hydrogen being set free: and the resulting alumina is dissolved by the alkali. Sulphur has no action upon it, even when it is heated to redness: but enters into combination with it at a high temperature. Its utility, as applied to domestic purposes, is increased by its not being tarnished by the sulphur which is in eggs and mustard. Sulphuretted hydrogen does not affect it: hence the air of cities, which always contains that compound, particularly when they are lighted with gas, does not dim its lustre, though it tarnishes silver with great rapidity. It may be used therefore as a reflector, with a jet of gas, even though the flame comes occasionally in contact with it. If sulphuret of ammonia is evaporated from it, there will be produced only a spot of sulphur, which will be driven off by continuing the heat. Polysulphuret of potassium will merely act on any iron or copper that may be united with it: but that substance cannot be applied to its purification, since it would more or less protect these metals, and prevent their complete removal. Metallic salts comport themselves with aluminium according

to the acids they contain; thus the chlorides act upon it, the sulphates do not. Aluminium fused with nitre is not affected by it, except at a high temperature, and then aluminate of potash is formed. The chlorides of sodium and potassium do not perceptibly act upon it when pure, and only very slowly when impure. Ordinary metals cannot resist the action of common salt—particularly as it is found in sea-water; even silver is slightly corroded by being boiled in water holding it in solution: and silver articles, which usually contain five per cent. copper, become dangerous when food is allowed to cool in them. Now, supposing silver and aluminium to be even equally affected in such cases, the latter, on account of its low equivalent, will give rise to a much smaller quantity of resulting salt: since a quantity of acid that will dissolve *one hundred* grains of silver, will dissolve only *eight and a half* of aluminium; and the physiological effects of the salts are very different. Other metallic chlorides, including even its own, are decomposed by it: and with a facility dependent on the elevated rank of the metal they contain. It does not combine with carbon: and in this respect has the advantage of platina, in the laboratory.

Compounds containing silicium are decomposed by aluminium, at a high temperature: yet we may fuse it in glass, or porcelain, because they are not in contact with it, unless some fusible substance is present; and hence, when we melt it in vessels which contain silicium, a flux is inadmissible. When aluminium containing silicium is dissolved in hydrochloric acid, siliciuretted hydrogen, a compound not long discovered, is disengaged, and is recognised by its peculiar odour: and the presence of silicium greatly assists the action of that solvent.

Aluminium combines also with boron: and the latter, like silicium, affects it properties. A very interesting compound, the *diamond of boron*, is produced by the intervention of aluminium. Boron assumes three states, corresponding with the three conditions of carbon—amorphous carbon, graphite, and diamond. Boron, in the state of *diamond*, is obtained by causing aluminium to act on boracic acid: it bears a heat sufficient to melt iridium, without change; and unites with oxygen, at the temperature at which diamond burns—but only on the surface, as it is protected by the boracic acid which is formed externally. It scratches the hardest diamond, by which alone it is exceeded in brilliancy and refractive power. It assumes three forms, having somewhat different qualities: one of them is exceedingly hard, and answers well instead of diamond powder, its crystals not being abraded by use: and the least hard is more so than corundum.

M. Hulot, director of the Mint at Paris, discovered that aluminium may be used in the galvanic battery, instead of platina, zinc being employed as the electro-negative element. It had long before been ascertained by Wheatstone, that it is as strongly negative as that metal. It becomes soiled, however, after a while, but may be cleansed by immersion for an instant in nitric acid, and washing with water.

Aluminium unites very imperfectly with lead, and only temporarily with mercury. It combines with small quantities of sodium, which changes its properties, and is with great difficulty separated from it entirely. It alloys with iron, in all proportions: but seven or eight per cent. makes it hard and brittle. Cadmium, tin, and zinc, render it fusible. Two or three per cent. silver, gives it a hardness and colour, equal to that of the silver alloy which is commonly used; a larger quantity destroys its malleability. If any chlorine is present, which, unless it is very pure, will probably be the case, the silver alloy soon blackens. Aluminium containing ten per cent. gold is softer than when pure, but not so malleable. Its most important combinations, however, are those which it forms with copper: if it contains two or three per cent. of that metal, it is aluminium bronze, a material well adapted for artistic, and many other purposes: if it contains ten per cent. it is as brittle as glass. Ten per cent. aluminium, and ninety per cent. copper, gives an alloy which, though harder than common bronze, laminates extremely well—particularly if it is heated, and is very ductile. The last is a definite compound, since it is in the proportion of nine atoms copper to one of aluminium, and great heat is disengaged during combination: hence its constituents do not separate by fusion and cooling. Its colour is that of green gold, which consists of gold and silver: and it is capable of as fine a polish as steel. Its tenacity is very great; and, compared with that of copper and iron, is found to be as follows—

Copper	190
Iron	280
Aluminium Bronze	434

It answers well for the material of axle-bearings, and similar parts of machinery: after having been used for six months with a steam-engine, it showed no wear; and it lasted eighteen months, in a machine which made two thousand two hundred revolutions per minute, while any other substance, in the circumstances, was found to last only three months. Possessing hardness without brittleness, it sustains shocks uninjured: and is well adapted for artillery, or the barrels of firearms.

It is difficult to gild or silver aluminium: baths of acid

sulphuret of gold, and hyposulphite of silver containing excess of sulphurous acid, have, however, been employed with tolerable success for these purposes. Other processes have been found to answer better, but their details are not known. Plates of copper or brass, and aluminium, strongly pressed together at a dark red heat, will unite; if it is attempted to treat gold and aluminium in the same way, the temperature required for cohesion will cause the two metals to combine. In depositing metals on aluminium, by means of the galvanic battery, we must not use acid solutions in which hydrochloric acid, or combined chlorine is present; nor must alkaline solutions of the metals—so useful in other cases, be employed. Pure aluminium may be easily coated with copper, by a bath of sulphate of copper. A patent was taken out some time ago, for plating with aluminium. The solution used was obtained by dissolving alum in water, adding ammonia as long as any alumina was thrown down; then filtering, adding distilled water, boiling with cyanide of potassium, and filtering when cold. And the article to be coated was suspended in it, by copper or brass rods connected with the zinc pole of a battery; a bag of alumina, or a piece of platina, being connected with the other pole.

It is difficult to solder aluminium, on account of our not knowing a flux that cleanses without altering it, or protects the solder without acting upon it; and a thoroughly strong joint has not yet been made in this way, although various methods have been adopted. Some persons deposit copper on the surfaces, and then apply the solder to unite them. With the process of M. Mourey, which is probably the best that has yet been used, the surfaces to be united are smeared over with a mixture of turpentine, balsam of copaiba, and lemon juice; they are then placed on hot coals, and the flame of a gas lamp, or of a self-acting blowpipe, is directed between them; after which, small pieces of an alloy containing six parts aluminium and ninety-four parts zinc, are placed in contact with them, and, when melted, are pressed upon them with tools made of aluminium. The surfaces thus coated, are next brought close together, and kept so by wires; after which, an alloy containing twenty parts aluminium and eighty parts zinc, is applied, in bits, to the points in contact outside, and is melted in with a lamp. When cold, the article bears filing and re-working.

We have now brought under the notice of the reader, almost everything of importance yet known regarding this interesting metal: and we do this the more willingly, because its general adoption is assuredly but a question of time. This must be greatly shortened, through the labours of ingenious and persevering experimentalists, who may be induced to give their attention to the subject, by the reasonable expectation of bene-

fitting the community, and at the same time deriving considerable profit from success. The method of obtaining it, by means of sodium, is the best that has yet been proposed; but it is more than probable, that one far less troublesome and expensive will hereafter be discovered.

HUNTING FOR DIATOMS.

Let us suppose the diatom collector and his friends to be setting forth, properly equipped with the necessary apparatus for securing and preserving the gatherings they may meet with. Here it will be as well to describe the arrangement of apparatus used by the writer of this paper in his expeditions after Diatomaceæ.

First of all, is a morocco leather bag, with a strap to go over the shoulders. This bag contains several pockets, to carry a dozen or more wide-necked bottles of say two-ounce capacity. A smaller leather case, with six narrow one-ounce phials, with wide necks, the phials slipping into partitions. This case is carried in the pocket of the shooting coat when out on a trip.

Next comes a box with small tubes and a camel-hair pencil, for painting off pure gatherings, or when it is inconvenient to bring home a larger quantity of the material.

In addition to the bottles and tubes some pieces of gutta-percha paper, or waterproof macintosh cloth, nine inches square, are very useful to wrap up Algæ, masses of Confervæ, and other diatom-yielding plants, into bundles, after slightly pressing out part of the water. These bundles, kept from unfolding by an elastic ring, are put at once into the bag. For scraping the surface of mud, the sides of jetties, etc., the writer uses a copper spoon, with a screw clamp, to fasten to the end of a walking-stick when used. On one side of the neck of the spoon is riveted a small knife blade, which forms a convenient means of cutting away portions of aquatic plants covered with diatoms, and lifting them out of the water.

The only lens necessary to the diatomist when out collecting is a Coddington; but the writer has found a small compound hand microscope very useful occasionally. This, with some slips of glass, are carried in a separate compartment of the leather satchel.

We will now suppose all these arrangements made, and the diatomists, who live in some large sea-port town, are sallying forth, as mentioned in the commencement of this paper.

A knowledge of the most likely places to look for Diatomaceæ is only to be gained after some experience, and it is the wish of

the writer to give the result of his experience in the matter, which has induced him to pen these lines. In mentioning the various species of Diatomaceæ in connection with given habitats and localities, it may be as well to say that the writer has in most cases found the species named in such localities; not necessarily in one particular district, but at various times and in different parts of the country.

We will now suppose the collectors are commencing their imaginary collecting tour, and, before leaving the town, let us take a stroll round the Docks—for here we may meet with material in places where such might be the least expected. For instance, let us examine the logs of Baltic or American timber as they come from the vessels. If the timber has remained for any length of time afloat before shipping, the logs are almost sure to have traces of Conferva, either fresh-water or marine, growing on them, and these, on being carefully scraped off, will, in all probability, yield diatoms to reward the collector. Some of the logs from the St. Lawrence or the Ottawa will yield us American forms, while logs from Dantzig will give us interesting gatherings from the Vistula and the interior of Poland.

Should a vessel be unloading "Kaurie spars," from New Zealand, or some of those gigantic "sticks" which have lately been imported from Vancouver's Island, we may, probably, be rewarded by finding beautiful Antipodean forms of Diatomaceæ on the former, and the exquisite *Arachnoidiscus* or *Triceratium Wilkesii* from the latter, perhaps even *Aulacodiscus Oregonus*.

Let us not go past these mahogany logs landing from Mexico or Honduras, as the case may be, without casting an eye over them, for these may have been rafted for some time in the sea before shipment, or may have brought down new or little known forms from the interior of Central America. Here, on the first log we examine, is a copious incrustation of a form, either identical with or closely allied to *Melosira nummuloides*, abundant likewise in our Docks. The gathering is so copious that it fairly glistens in the sun.

Let us also scrape away some of the shelly incrustation of *Balanus*, which completely covers some of the logs, for possibly among this we may find that exquisite American form *Terpsinœ musica*, so called, I suppose, from the costæ appearing like so many musical notes.

Here are some fishermen just coming in. Let us examine their nets, for these men are trawlers, and have been fishing in deep water, and the meshes of their nets may still have diatoms bearing Algæ attached to them. On such Algæ we may probably find *Rhabdonema arcuatum* or *Adriaticum*, *Grammatophora serpentina* and *marina*, with species of parasitic *Synedras*; possibly the singular *Synedra undulata*, may reward our search.

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Some of the oyster shells from deep water are worth examining for marine Algæ, or, what is even better, the greenish, leathery-looking ascidians attached to them. The ascidians are regular feeders on diatoms, and their stomach contents often yield a rich harvest of deep-water forms difficult to obtain in any other way. Perhaps we may be securing the rare *Biddulphia regina*, at any rate, *Bidd. Baileyii* and *aurita*. We will take some for future examination, for the curious *Rhizosolenia styliformis* is almost sure to be there.

Let us step into a boat and examine that ship's bottom and sides, which look so brown with a growth of conferva and barnacles. Here the spoon becomes of use. Scrape very gently where the deposit is the darkest in colour, and let us see what we have got—*Achnanthes longipes* and *brevipes* in abundance. These are common enough elsewhere in the timber ponds, so we will only secure the little thing in zig-zag filaments, for this is probably *Diatoma hyalinum*, or, perhaps, the rare *Hyalosira delicatula*.

Is it not singular that such delicate filaments, hanging together by the angles of the frustules, should be able to withstand the rushing of the vessel through the water during the long voyage she has just completed?

The ballast heap must not be passed without examining. Here are stones densely covered with marine Algæ and Corallines, which we will scrape off, and store away for after examination. *Biddulphia pulchella*, *Amphitetras*, *Grammatophora serpentina*, or possibly some of the beautiful foreign species of *Aulacodiscus*, may reward our trouble, for this ballast is brought from all parts of the world. The only matter of regret is the difficulty in ascertaining the exact localities.

Let us now take some of the *Zostera* which is being landed on the quay in large bales; it is extensively imported from the Baltic as *Alva marina*, for stuffing chairs and mattresses. *Cocconeis scutellum* and *diaphana*, with *Epithemia* and a medley of other forms, are generally found parasitic on the *Zostera*, and may be easily separated by maceration in weak acid.

But what are those brown bundles landing from the steamer? These are "Dutch rushes," for coopers' purposes and chair-bottoms, and are well worth examining, for, growing as they do in brackish water in Holland, the sheath at the base is often completely coated with diatoms, *Coscinodiscus subtilis*, for instance, with other good things, such as *Eupodiscus argus* and *Triceratium favus*.

Nor must we pass these cargoes of bones discharging into lighters. See, some of the larger bones have evidently been lying in the water some time, for they are covered with a green incrustation. Let us scrape away the incrustation, for we may

find among it the fine *Synedra crystallina* or *undulata*, together with valves of *Coscinodiscus* and *Eupodiscus*. Many good gatherings have been procured from this source, especially from cargoes coming from Constantinople, Smyrna, and the Black Sea.

Ask this sailor if he has any foreign shells still in the rough state; if he has any for sale, they are certainly worth securing for the small Algæ and Corallines found growing on them. These, on being cleaned, often yield splendid results. Many of the most beautiful and rare species of *Campylodiscus* have been obtained from this source. The Californian *Haliotus* shell is almost certain to yield the fine *Aulacodiscus Oregonus*, *Arachnoidiscus*, *Hyalodiscus cervinus*, and *Biddulphia Roperi*; while the *Haliotus* from New Zealand will probably furnish the rare *Aulacodiscus Beeveriæ* and *Macraeanus*.

The West Indian *Strombus* shells invariably yield beautiful forms, such as *Campylodiscus-ecclesianus*, *ambiguus*, and *imperialis*.

Vessels with guano are worth visiting. The Peruvian guano, when properly prepared, yields the magnificent *Asterolampras* and *Aulacodiscus scaber*; while the Bolivian is even richer in fine things, such as the superb *Aulacodiscus formosus* and *Comberi*. Californian guano yields, among an infinite variety of forms, many of great beauty and rarity, such as *Aulacodiscus margaritaceus* and *Biddulphia Tuomeyii*. Algoa Bay is frequently rich in *Aulacodiscus Petersii*; and, finally, the Ichaboe guano, *Eupodiscus Ehrenbergii*, and other good things.

The old mooring anchors and cables which are now lying on the quay are covered with a marine incrustation, which on examination will be found deserving of notice.

We will now take a stroll towards the timber ponds, where the timber often remains afloat for years. Here we see ample traces of the objects of our search. The sides of the logs seem quite covered with a tangled mass of the filamentous forms; but before we bottle up any of them, let us collect with the spoon some of the brown pellicle which covers the surface of the water. This proves to be a very pure gathering of *Amphiprora constricta*. Then let us collect some of the green *Ulva* and *Enteromorpha*, growing on the sides of the timber, which seems so brown and furry. With the Coddington lens we find the brown tint is owing to a dense parasitic growth of *Achnanthes longipes* and *brevipes*. The long brown filaments are principally *Melosira nummuloides* and *Borrerii*, with *Schizonema crucigerum* and *Dillwynii*, mixed with *Bacillaria paradoxa*, shooting into long filaments, then suddenly retreating until the filament is closed again, one frustule sliding past the other in a most marvellous manner. By the way, this species will live,

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and even thrive, quite well in perfectly fresh water. Mixed with the *Bacillaria*, we find *Nitzschia sigma*, and other free forms.

The wooden piers running out into the river are brown with a covering of *Homœocladia sigmoidea*, *Pinnularia Johnsonii*, and *Navicula ellipsis*. On another wooden breakwater we find *Pleurosigma scalprum* and *Navicula mutica*.

Leaving the immediate vicinity of the docks we come to a maze of ditches, to which the salt-water has access during spring tides, and these ditches are often very rich in Diatomaceæ. Let us commence operations here by collecting this brown covering from the mud. Here we have *Pleurosigma angulatum*, *Fasciola*, *Strigilis*, *Hippocampus*, *Nitzschia sigma*, and *Surirella gemma*. Such gatherings may afterwards be entirely cleaned from the mud by covering the outside of the bottle with black cloth, and letting it stand for some days in the sun. The diatoms by this time will have worked themselves to the surface, and the thick brown layer will be found quite free from impurities. This plan, if carefully carried out, rarely fails. The brown floating scum must by no means be neglected, for on bottling some we find we have secured a good gathering of *Pleurosigma Fasciola*, *macrum*, and *delicatulum*, with, perhaps, *Navicula ambigua*, and other good things.

Proceeding to another ditch, we will take a dip from the mass of brownish stuff which coats the weeds. Well, here indeed is a capital haul, for we have *Nitzschia bilobata*, *Brebissonii*, *vivax*, with *Tryblionella gracilis*, *Navicula amphisbœna*, *Pinnularia peregrina*, and *Cyprinus*.

Further on we pull out some of the weeds which are covered with brown furriness, and we have a gathering of *Synedra fulgens* and *Amphipleura Danica*; while on the mud we obtain a copious one of *Stauroneis salina*, *Nitzschia dubia* β, with *Navicula minutula*.

But what can this brown hair-like mass be, growing parasitically on the reeds and floating pieces of stick? On examination it will prove to be pure *Melosira Borrerii*, which we will bottle up with great satisfaction.

Further on we come to a large lagoon, and find therein some plants very promising in appearance, and well worth gathering. These yield us afterwards a fine mass of *Amphiprora alata* and *paludosa*, *Pleurosigma Strigilis*, *Amphora salina*, with *Surirella Brightwellii*.

Mind how you step over this boggy ground, with the ink-black mud, smelling so unpleasantly of sulphuretted hydrogen. In spite of the smell, we shall probably get something to reward us. Collect carefully the brown covering from the mud, and you may find *Navicula elegans*, *tumeus*, *Nitzschia dubia*,

Epithemia musculus, *Amphora affinis*, with *Pinnularia Cyprinus* and *peregrina*.

We now approach the banks of a canal, into which the brackish water sometimes gains access. Let us hook out some of the *Potamogeton* and other weeds. Well done, we have here something that will reward us for our fatigue. Examine it with the Coddington; the circular discs are valves of the rare *Cyclotella punctata*. Mixed with these we find *Campylodiscus cribrosus*, *Bacillaria paradoxa*, with a host of other both fresh and salt-water forms.

With the tweezers let us now carefully pull off some of the brown tufts growing on the clay banks of the river. This looks like some stunted Conferva. On examination with the lens, the filaments are found crowded with rows of little sigmoid things, for all the world like miniature specimens of *Pleurosigma Balticum*. This is a prize again, being no other than the rare *Colletonema eximium*.

Leaving this locality, let us proceed a few miles down the river towards its embouchure, and where the water is salter. Being low tide, we see for miles the mud is coloured of a dark chocolate-brown tint, owing to the presence of millions of *Navicula Jennerii*. In the large lagoon, formed by the salt-water getting over the embankment during spring tides, we shall probably find an abundance of good things; among these many of the filamentous *Schizonemas*, *Rhipidiphoras*, and *Podosphenias*, and even *Licmophora flabellata*. Proceeding even further down the river, the mud gradually disappears, sand takes its place, and afterwards we come to the open sea, where the coast is in places guarded by rocks. Here is a fine field for the purely marine forms. Let us gather some of the wiry green tufts of *Cladophora rupestris*, one of the best of the diatom-bearing Algæ. The tips of the *Cladophora* are quite brown with a parasitic growth of *Grammatophora marina* and *macilenta*, together with *Rhabdonema arcuatum*, *Cocconeis scutellum*, and *Gomphonema marina*. On the other Algæ, growing among the rocks, we find masses of *Podosphenia*, and perhaps the easily-overlooked *Hyalosira delicatula*. The brown hair-like mass floating about, but attached to the stones, is *Fragillaria striatula*, and some of the filamentous *Schizonemas*.

In the rocky pools left by the tide are some masses of *Corallina officinalis*, growing in dense tufts. This Algæ is an excellent diatom trap, collecting the floating frustules among its tangled branches. We must, therefore, select a good stock of the *Coralline*, lifting it out of the water with as little violence as possible, for fear of washing off the diatoms.

Washing afterwards in acidulated water will liberate the frustules, and then we have probably a fine gathering of the

beautiful *Eupodiscus Ralfsii*, with *Eupodiscus subtilis*; perhaps also *Amphiprora lepidoptera*, and other good forms.

The sand in sheltered places, you will observe, is brown in the hollows of the ripple marks. This is caused by millions of diatomaceous frustules, and we must by all means take home a good store of the brown sand which by washing easily yields up its riches.

Having spent so much time on the marine and brackish water gatherings, let us turn inland and proceed where the tide ceases to have any influence. To make sure of this, we will take the rails and go to the rocky hills some ten miles distance. Having arrived there, let us examine, in the first place, this rocky streamlet, for I see traces of a brownish covering on the stones, and also some pretty long streamers. Lift the filaments out gently, or you will get little into the bottle. On examination at home you will probably detect *Odontidium mesodon*, *Himantidium undulatum*, and *Arcus*, with *Tabellaria fenestrata* and *flocculosa*.

Proceeding a little further, we come to a little waterfall trickling down the surface of the rock, and gradually finding its way to the stream. The brown, velvety covering on the stones looks very promising for our purpose, and if I mistake not, we shall be well rewarded for our trouble in carefully collecting a bottle full of the material, for we have a good gathering of the beautiful *Gomphonema geminatum* and *ventricosum* mixed with the minute *Achnanthidium lineare*. The brown mass completely covering the stones in the bed of the stream is *Cocconema lanceolatum*, not often found so pure.

Let us see what causes the green colour on the surface of the mud in the roadside puddle. Ah! this is indeed a treasure, for it is seldom that *Navicula cuspidata* occurs as perfectly free from mixtures. The green colour is also remarkable, being so different from the usual brown endochrome of most diatoms.

Here is another roadside puddle left by the recent rain, and see what a brown coating has grown at the bottom in so short a time. At any rate we have here *Diatomaceæ* in abundance, though small in size, probably *Nitzschia palea* and *Pinnularia pygmæa*.

Proceeding further inland we are supposed to be passing a water-mill, and as the mill race is covered with confervoid growths, let us examine some of the coating from the wooden aqueduct. The brown streamers are in all probability *Diatoma vulgare* and *elongatum*, and the beautiful stellate form is the local *Asterionella formosa*, which, by the way, seems to select its habitat always in some out of the way place, such as the present one in the mill aqueduct, water tanks, and reservoirs.

Having climbed up some distance on the hill sides, let us

collect some of the weeds from the sides of the boggy pool, for in such localities we may expect to find some of the rarer alpine forms, *Navicula rhomboides, obtusa, Pinnularia divergens, lata,* and *Alpina,* for instance. The pale green flocculent mass growing in quantities like a conferva, is well worth collecting, for it is a pure gathering of *Tabellaria flocculosa* and *fenestrata.*

In tramping over this quaking bog it is well to roll up a bundle of the *Sphagnum,* for on afterwards squeezing out the water, we may be rewarded by finding some of the rarer species of *Pinnularia,* such as *Hemiptera* and *Alpina.*

Before leaving this rocky part of the country for the flat country below, let us scrape some of the brown mucus from the face of the dripping rocks, for it will probably yield such forms as *Epithemia, Cocconeis Thwaitsii, Navicula Trinodis, Denticula sinuata,* etc.

The weather being warm we will quench our thirst at the little spring in the cavern-like hollow in the rocky roadside. Observe, the roof of the little cavern is quite covered with a chocolate-brown mass, which feels rough and gritty to the fingers. Here is a splendid and pure gathering of *Orthosira arenaria,* and I recommend you to take a good store of it away with you, for it is seldom one finds this fine form so pure and unmixed.

Proceeding towards the low country let us take a scrape from the side of this horse-trough, for it is quite brown. It is well we have done so, for it is a nice pure gathering of *Cyclotella operculata* and *Pinnularia pygmœa.*

Passing a little further on we come to a clump of ash trees, with a crop of moss growing on their trunks. Perhaps you may smile when I proceed to peel off this moss and store it away in a bundle in my satchel. On washing the moss afterwards, however, I may be rewarded with some of our most local and rare species, viz. *Orthosira mirabilis,* mixed with *Navicula tumida, Pinnularia borealis,* and *Orthosira spinosa.*

Having secured a bundle of moss from the tree trunks, we will take another from the roof of this old thatched cottage, the north side of which is quite carpeted with beautiful green moss. This will probably yield *Nitzschia Amphioxys* and *Pinnularia borealis.*

The white-coloured stratum of earth exposed in the cutting on the roadside must now be examined, for it is probably a deposit of fossil, diatomaceous earth, in which case a large piece must be secured.

These fossil deposits are generally composed of a compact mass of Diatomaceæ of recent as well as extinct species. The deposit we are at present examining is several feet thick, and has at some remote period formed the bed of a lake, the

diatoms accumulating at the bottom until the present thickness was attained. You will observe that the endochrome has been removed by long rotting, and the entire mass is now composed of the pure white siliceous valves. Pray also observe that this richness in silex suits the cereal crops growing over it, but does not seem to furnish much nutriment to the potatoes and turnips.

The adjacent peat beds may also be examined, for frequently rare Diatomaceæ are found in the turf which is cut for fuel.

The dark, hair-like mass growing on the woodwork of this sluice-gate, is a nice pure gathering of *Schizonema neglectum*, the frustules arranged in regular rows in the interior of the long filaments.

Before leaving this pond let us pull out a mass of the *Myriophyllum*, which seems rusty in colour. Well! here is a medley of forms, but the gathering is worth bottling up, owing to the abundance of *Amphipleura pellucida*.

The clear ditch by the roadside is a likely place for such forms as *Pleurosigma attenuatum*, *Spencerii* and *lacustre*, *Nitzschia linearis* and *tenuis*, *Surirella ovata*, *Navicula elliptica* and *Cymbella maculata*.

The yellow mass attached to plants a little further on is *Cyclotella operculata*, *Amphora ovalis* and *Nitzschia sigmoidea*, while the brown covering on the *Anacharis* is *Gomphonema tenellum*, *dichotomum* and *curvatum*. The stones in the running beck, issuing from the clear spring close by, are covered with long, yellowish-brown streamers, which are well worth collecting. Take them out very gently, for they are very fragile and likely to drop again into the water. The species is the beautiful *Meridion circulare*, with *Melosira varians*.

At the bubbling spring itself, which forms the head of the streamlet, the sand, which is tossed and heaved about by the ascending water, seems tinted of a brown colour. Let us secure some of the sand, when we shall find the brown colour is caused by a dense parasitic growth of *Odontidium Harrisonii* quite pure.

Further on the dark brown streamers must be collected, for here are two species of *Fragillaria*, *Capucina*, and *virescens*, mixed with *Diatoma elongatum*. The stones and aquatic plants are likewise covered with a dense brown coating of *Synedra radians*, and *Ulna*, species found in almost every clear water-ditch.

The boggy place where the plants are coated with a yellow coating of the oxide of iron, is not to be passed without collecting a little of the light flocculent surface mud. This will be almost sure to yield some fine diatoms, such as *Campylodis-*

T. S. Cobbold, del.

Choroid, cones of the Retina, Psorosperms, &c.

cus spiralis, Pinnularia nobilis, Stauroneis Phœnicenteron, Surirella splendida, and *Cymatopleura solea.*

Here we must finish our day's work, having arrived at the railway station, from whence we proceed home with our treasures. The work of collecting has been finished, yet much remains to be done before the material is cleansed and mounted on slides for microscopical investigation.

Let us hope our fatigue has not been in vain, but that the store of riches we have collected together, will furnish us with ample material for much interesting study and instruction.

THE EYE OF THE COD-FISH.

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FROM the earliest periods of physiological inquiry, the organ of vision, especially in connection with man and the higher animals, has uninterruptedly occupied the attention of the anatomist, the physicist, and the philosopher; and yet, notwithstanding the instructive teachings of a most voluminous eye-literature, there remain difficulties to be solved both as regards the visual functions of the organ and the structural elements concerned in the production of its optical effects. In the view, therefore, of contributing something towards our knowledge of the histological peculiarities found to occur in the eye of fishes, I hereby propose to dwell more particularly on the existence of certain parasitic vegetations in the sclerotic coat, on the structure and functions of the so-called choroid gland, and on certain artificially-produced phenomena in connection with the cones of the retina.

Recent discoveries respecting the microscopical anatomy of the vertebrate eye have, in most instances, resulted from examinations of the eyeball after it has been immersed for a greater or lesser period in solutions of chromic acid. This method appears to have originated with Dr. Hannover, of Copenhagen, who published a series of papers on the subject in Müller's *Archiv,* during the year 1845. In 1851, Dr. Hannover came over to this country, bringing with him a number of preparations illustrative of his recorded views as to the structure of the vitreous humour in different orders of mammalia; and at a meeting of the Physiological Society of Edinburgh, I had an opportunity of examining them attentively. These choice preparations unequivocally demonstrated the cor-

rectness of the descriptions and figures given by Dr. Hannover; but I then pointed out, and subsequent investigations have confirmed the truth of my statements, that the assumed laminated character of the vitreous body had no real existence in nature, seeing that the laminæ only made their appearance after the eyeball had been steeped in a solution of chromic acid or some other coagulating agent.

During my antecedent investigations into the anatomy of the eye—the results of which were only partially recorded in my graduation Thesis, for which the Edinburgh Medical Faculty awarded me the University Gold Medal in 1851—I had followed out the indications initiated by Dr. Hannover, and had thus satisfied myself as to the danger of drawing hasty conclusions from the occurrence of appearances so palpably the result of chemical action; yet, at the same time, it should be acknowledged that the application of chromic acid solutions has materially assisted us in the determination of the relations and component parts of the retina, especially in the hands of Professor Kölliker and Heinrich Müller. Even here, however, as will be shown in the following pages, the true characters presented by the individual elements of the retina have been either changed or altogether obliterated; and as regards the vitreous body, the fallacy of supposing it to be made up of delicate membranous laminæ is evident from circumstances altogether independent of microscopical inquiry. Thus, if several punctures be made through the hyaloid covering of the vitreous mass in a recent condition, its fluid contents will rapidly escape, and all that we shall ultimately find left will be the external tunic and a few septa or membranous prolongations from the internal wall of the hyaloid, these together constituting scarcely a fiftieth part of the bulk of the entire vitreous body.

I may premise, also, in regard to the so-called *choroid gland*, that the anciently received opinion, supported by John Hunter, as to its muscularity, is still maintained by many at the present day; at least, they aver that this organ is in some way or other concerned in the adjustment of the crystalline lens and vitreous body to different focal distances. At a later period, Sömmering doubted whether it were glandular, vascular, or muscular; whilst Baron Cuvier, who supplied accurate descriptions of its ordinary appearance in various fishes, returned to the still older notion of Haller, that its structure partook more of the character of a gland. Subsequently, I believe, Cuvier took up with the opinion that the choroid gland was to be classed with erectile tissues, but with whom this idea originated I am not able to state. In later times, amongst others, Dr. Arthur Jacob, of Dublin, diligently applied himself to the solution of this question, but at the conclusion of his excellent article,

"Eye," in Dr. Todd's *Cyclopædia of Anatomy and Physiology*, he simply observes:—"The organization of the part is certainly not merely vascular, as stated by Cuvier, and undoubtedly bears a stronger resemblance to muscular than any other structure; it also retains the peculiar colour of red muscle after all the rest of the eye has been blanched by continued maceration in water."

On recently consulting Leydig's *Lehrbuch der Histologie*, I was surprised not to find any description of the organ, in question, which is the more remarkable as the author has given a good account of the *processus falciformis* and *campanula Halleri*. It seems, therefore, that the now very generally received opinion as to the erectile character of the so-called choroid gland is still deemed worthy of credit, and further, that in virtue of its erectile properties, it is, to use Dr. Carpenter's words, "concerned in the adaptation of the eye for distinct vision at different distances." To me it appears that a due consideration of the facts and arguments which I shall immediately record, are sufficient to demonstrate the erroneousness of these views.

If the perfectly fresh eye of a full-grown cod be removed from its socket, three large vessels will be seen to enter or emerge from the sclerotic covering; namely, a vein passing out from within the optic sheath, an artery entering immediately behind the sheath, and a vein situated further back, at a little distance from the circumferential border of the tunic. If the loose cellular connective tissues be next dissected off from the sclerotic, the latter will be found to consist of three distinct layers; that is to say, of an outer and inner fibrous membrane which inclose between them the true cartilaginous coat. The first-mentioned layer consists of coarse fibrous tissue closely investing the cartilage, but the internal connective layer is delicate, transparent, and easily separable from the middle coat. A thin verticle section of the latter, or true sclerotic layer, displays, under the quarter-inch objective, a hyaline, ground-glass-like matrix, in which the characteristic cartilage cells are numerous, thickly set, and rather irregularly disposed.

In addition to these ordinary structural characters, it is not uncommon to find, especially in old fishes, milky-white patches partially or entirely embedded in the cartilaginous matrix, and they not unfrequently project considerably from the inner true sclerotic surface. These striking-looking patches vary in size from a pin's head to that of a threepenny-piece, and invariably present a more or less rounded, oval, or semicircular outline, the borders of which are usually cleft and lobed in so regular a manner that the entire mass frequently exhibits a curiously stellate appearance, such as is accurately represented in the accom-

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panying plate (Fig. 1). It is probable that these bodies have been seen by observers in this country, as their contents are evidently referable to the so-called Psorospermiæ described by J. Müller, Creplin, Leydig, and others on the Continent. Some years ago they were brought under my notice by my friend Dr. Drummond, at Edinburgh, when we both endeavoured to ascertain their true character. As then demonstrated, and in accordance with my more recent examinations, the patches in question appear to form a sort of nidus for the lodgement, protection, and development of the minute cells which are found by myriads in their interior. These little bodies are evidently parasitic in their nature, and forcibly remind one of the so-called *pseudo-naviculæ* of *Gregarina*. I think that they are of a vegetable nature; this algous character being also, in my opinion, applicable to the somewhat similar parasitic cells described by Mr. Lubbock, F.R.S., in his valuable memoir "On the Ova and Pseudova of Insects," in the *Philosophical Transactions* for the year 1857. Be this as it may, I have further to remark, that in specimens recently subjected to microscopic analysis, the cellules measured about the 1-4000th of an inch in their longest diameter, and they presented an oval figure, being at the same time slightly pointed at either extremity (Fig. 2). The cell-wall itself is double; but by far the most striking peculiarity consists in the universal presence of two bright, highly refracting nuclei, usually located side by side at one end of the cell cavity. They also exhibit a pale yellow colour, due apparently to a clear fluid surrounding the nuclei. In no instance have I observed any metamorphotic appearances, neither have I seen any altered condition of the cells, such as might indicate an earlier or later stage of growth. On the addition of caustic potass the colour of the cellules quickly disappeared, and they performed a series of peculiar jerking movements, due, it would seem, to the bursting of the outer cell-wall; a little sarcode matter appeared to make its escape, but the oval form of the cells remained unaffected.

Between the internal separable layer of the sclerotic coat and the *marsupium* of the choroid there exists a clear albuminous fluid, which, in the perfectly fresh condition of the eye, is entirely free from blood corpuscles, sarcode globules, and other particles; but this fluid is not uniformly disposed between the two membranes, because at certain spots, and especially in the neighbourhood of the optic nerve, the marsupium is intimately blended with the inner sclerotic layer above mentioned. The fibrous marsupium itself is in great part made up of, or rather contains, numerous cylindrical rods, which offer a decidedly inorganic crystalline aspect, but which do not consist of carbonate of lime. The Neapolitan naturalist, Delle Chiaje,

designated them eye-stones, and I have represented a few in the upper part of Fig. 3. When I added acetic acid there was neither effervescence nor disintegration, although, on the other hand, the application of strong caustic potass gradually caused their dissolution. Between the marsupium and the vascular layers of the choroid there exists a fibrous membrane coated with yellow-brown pigment cells, the latter being characteristic of the *lamina fusca* of authors. These coloured cells, shown in Fig. 4, are somewhat irregular both in form and size, and contrast strongly with the true black pigment cells, which are much larger and particularly abundant at the ciliary margin of the choroid. One of the latter and two sarcode globules are represented in the lower part of Fig. 3, magnified about two hundred diameters linear.

The vascular choroid itself consists of two distinct layers, the outer one constituting the true choroid, and the inner being the so-called *tunica*, or *membrana Ruyschiana*, which is partly separated from the former by the intervention of a non-vascular fibrous membrane, containing neither nuclei nor granules. The choroid proper consists of vessels united by connective tissue, the latter element being particularly abundant in the neighbourhood of the vascular trunks before they suddenly divide to form the so-called choroid gland; the inner layer, or *membrana Ruyschiana*, is comparatively thin, becoming intimately blended with the former as it approaches the ciliary circle. To the naked eye the choroid gland of the cod invariably displays the figure of an irregularly horseshoe-shaped band, the incomplete portion of the band occupying the anterior aspect of the eyeball in relation to the longitudinal axis of the fish. In some instances the continuity of the band is interrupted at two or more distinct places, but in this case the lineal arrangement of the independent segments combines to produce the characteristic form above described.

If in another fresh eye of the cod fine injections of vermilion and artificially prepared ultramarine be severally thrown into the vein emerging from the optic sheath and the artery entering the sclerotic immediately behind the latter, both injections, if not too violently forced from the syringe, will be found to have filled the trunks of the choroidal arteries and veins as far as the inner margin of the band; and if, thereafter, the eyeball is laid open by a clean tranverse cut from before backwards, the true choroid being also carefully isolated from all the other membranes, the operator will probably be rewarded for his trouble by the production of a preparation of the posterior half of the choroid very similar to the one depicted in the accompanying plate (Fig. 5). The illustration, however, represents the parts enlarged to twice their natural diameter,

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the minuteness of the vessels not permitting a clear picture of their disposition had they been drawn of the natural size. In the several instances in which I have thus treated the eye, I have never found the colours to pass into the vascular continuation of the true choroid beyond the band, neither into the band itself, nor even, so far as I can remember, into the *membrana Ruyschiana;* and thus it is seen that naked-eye experiences taken by themselves are calculated to convey the idea of the non-vascularity of the so-called gland. By a series of careful microscopic investigations, however, I have satisfied myself as to the inaccuracy of this inference, and I therefore now proceed to show what is the true character of the structure in question.

If a thin vertical or horizontal section be removed from the choroid band, and placed under a quarter-inch objective, the smaller arterial and venous branches will be seen to divide suddenly into multitudes of minute capillaries, the latter taking their origin at a point precisely corresponding with the clearly-defined line of limitation indicated by the stoppage of the artificially-introduced pigments. These small vessels are closely connected to one another by their own walls, and not by the intervention or extension of any fibres from the connective elements of the choroid. They are all arranged in a simple, linear, parallel manner, and their width does not appear to exceed that of the short diameter of the blood corpuscles, the admeasurements of the latter being about the 1-2500th of an inch long, and the 1-3500th of an inch in breadth. In fresh eyes the capillaries are always found gorged with blood, and when I recently succeeded in isolating, more or less completely, a few of the vessels of the band, one of them was seen to contain blood corpuscles arranged in single file. As shown in the accompanying diagram (Fig. 6), the capillaries are straight and of uniform diameter throughout; moreover, they do not give off any branches or dilatations such as are found to occur in the true erectile structures.

From beneath the external border of the horseshoe-shaped band the outer vascular choroid is supplied with numerous vessels, which for the most part proceed in a radiating manner to the circumferential border of the choroidal membrane. These vessels are obviously a continuation of the reunited capillaries of the band, but their mode of origin is not so easily seen at the outer as at the inner border of the band. As previously remarked, a simple fibrous layer is interposed between the choroid proper and the *membrana Ruyschiana,* the latter being also lined internally by another non-vascular membrane, which is entirely destitute of fibres (Fig. 7). This membrane is applied against the baccillary layer of the retina, and consists of a

delicate membrane almost entirely made up of minute, closely-aggregated granules.

Turning now to the consideration of the retina, I may, in the first place, observe that it is well-nigh impossible to obtain a thin vertical section of this membrane, unless the eyeball has been previously immersed in a strong acid solution; at least this is the case with the posterior division commonly described as Jacob's membrane. Very soon after death, the relations of the delicate and complex elements of this structure are lost by disintegration, but a careful examination of the broken-up tissues themselves affords a clearer insight into their true histological character than can possibly be obtained from the artificially consolidated section. Whilst the latter method, therefore, demonstrates the actual relations of the component tissues of the organ, the former conveys a truthful conception of the nature of these elementary particles.

Under ordinary circumstances, when a small portion of the retina of the cod is subjected to microscopic examination, with the one-fourth or one-fifth objective, all that we see is a more or less confused mass of semi-transparent tissues, in which, however, the following elements may be distinctly recognized: a fibrous matrix inclosing oval nuclei, dense layers of granules, nerve filaments with or without ganglionic enlargements (Fig. 8); rod-like fragments which are portions of the well-known *baccillæ* variously twisted, and frequently tapering to a narrow point at one end (Fig. 9); and large oval corpuscular bodies which are neither more nor less than the so-called *cones*, whose character varies considerably in different members of the vertebrata. If the eye be not perfectly fresh, the cones display the utmost irregularity of outline, some being cylindrical, some club-shaped (Fig. 10); many of them split up longitudinally (Fig. 11), and showing a central cavity (Fig. 12); a few perfectly spherical (Fig. 13), and others oval (Fig. 14), in which case the contents of the corpuscles are usually confined within a second investing membrane, the latter being more or less widely separated from the outer covering.

These appearances, though in part abnormal, are not altogether uninstructive; but when the retina of a fish more recently killed is examined, it will then be seen that all the foregoing illustrations represent only the separated halves of the cones which are double in the cod (Fig. 15) and its allies, as indeed has also been shown to obtain in the perch by the researches of Kölliker and H. Müller. Although the twin-cone last referred to does not exhibit the true normal condition of these corpuscles, yet, before going further, I may here remark that these various demonstrations seem to prove the cones to possess a double envelope, the inner one inclosing a

dense mass of extremely fine molecules, agglutinated together by an albuminous fluid, which becomes gradually less dense towards the centre of the corpuscular cavity. The half-cone may, therefore, not inaptly be compared to an ovum in which the chorion, yelk-membrane, and granular yelk respectively occupy the same relative position as the parts just described. Such are the appearances ordinarily found on examining the retina of the cod, a small appendage being occasionally visible at one end of the cone (as shown in Fig. 10), which, however, drops off immediately any floating particles strike against it. In the case of the twin-cone (Fig. 15) here represented, there were two appendages adherent, both of which I saw detached in the manner just indicated. Mr. Nunneley, of Leeds, who describes the appendage in question as "the conical leg" of the cone, has noticed similar changes to "occur within a very short time after death;" but notwithstanding the extent of his recent and valuable researches on the retina, the antecedent phenomena which I am now about to detail do not appear to have come under his observation. My attention was first called to a special examination of these cone structures in the cod at a meeting of the Brighton Microscopical Society, held in the evening of the 6th of December last, and as I derived great assistance from the distinguished members of that society who were present, I think it right to allude to the particular circumstances under which certain observations, preceding those I have just recorded, were made; and in doing this I shall describe the mode of occurrence of a series of phenomena in connection with the cones, which I have subsequently and independently confirmed. I had taken with me to the meeting a perfectly fresh cod's eye, with the view more particularly of re-examining the choroid gland under Mr. Hennah's powerful "Smith and Beck" microscope, which is fitted with Wenham's binocular arrangement. After examining the choroid band, without, however, obtaining any other results than such as I had previously acquired from my own instrument (by Ross), I placed a portion of the retina under the one-fifth objective, when the following facts were elicited:—Conspicuous beyond any other histological element were numerous oval corpuscular bodies, or perfect twin-cones, all of which were slightly truncated at either extremity, symmetrical in form, and divided longitudinally by a straight line passing in the middle line from pole to pole (Fig. 16). All of them in the first demonstration exhibited these characters. Following Mr. Hennah's advice, I had in this demonstration only added to the slide a little of the albuminous fluid, which is naturally present in the eyeball, but when this medium was supplanted by the addition of a drop or two of clear, cold, hard water, the effect at once produced upon

the corpuscles was as remarkable as it was unexpected. The cones now displayed a series of curious phenomena; all of them began to alter in form, the two halves partly separating from one another, whilst each half at the same time gradually assumed a more or less completely oval outline. Usually the upper poles of the twin-corpuscles retained somewhat of their normally truncated figure, and at this end they appeared broader than at the other. Contemporaneously with these changes, the borders of a clear transparent membrane connecting the two halves of the cone became visible, and there also appeared two minute globular vesicles, one at either lower pole of each half of the cone. These seemed to be formed by the outward extension of the external investing envelope, and they invariably occupied the position indicated in the accompanying drawing (Fig. 17). These saccular appendages, gradually increasing in size, were evidently not the result of mere endosmosis, inasmuch as there appeared within them distinct evidences of another structure, which to all present appeared to be a filament spirally folded upon itself. This coil continued to unroll and extend itself until at length the globular sac assumed the condition of a cylindrical tube, the enclosed filament at the same time losing its essentially spiral aspect (Fig. 18). Many of the cones had by this time separated more or less completely into their characteristic halves, and the delicate outer membranes surrounding the partially uncoiled filaments subsequently disappeared (Fig. 19). No further changes affecting this latter structure, were observed that evening, but during my examinations of another fresh eye, made next day with Mr. Murray's "Oberhaüser" microscope, I saw one example of the half-cone, in which the filament had unrolled itself to the fullest extent of which it appeared capable (Fig. 20). In addition to the above particulars, I have further to remark that when acetic acid is added to these cones, they immediately lose their normally plastic character, becoming brittle, less regular in outline, and refract light more powerfully. Caustic potass, on the other hand, gradually dissolves them. Finally, it remains for me to state that the twin-cones of the cod, in their unaltered condition, present an average measurement of 1-500th of an inch in length by about 1-800th of an inch in breadth. On the addition of water they attain a length of 1-400th, but some normal cones which I have since examined measured only the 1-650th of an inch longitudinally.

It has occurred to me as possible that some might consider the filament shown in Fig. 20 to be referable to the class of structures known as the radial filaments of Müller, which are said to be normally connected to the upper end of the cones. Such an interpretation, however, I do not think probable,

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although it must be confessed that the filament in question bears a very considerable resemblance to the radial filaments attached to the similar twin-cones of the perch as represented by Kölliker and H. Müller in Ecker and R. Wagner's beautiful *Icones Physiologicæ*, plate 19, fig. 13. In support of my opinion, however, that the protruded filaments I have described are neither more nor less than the so-called baccillary prolongations (Zapfenstäbchen) from the outer, choroidal, or lower ends of the cones, I may observe that even in the human retina the true baccilli of the cones have been seen expanded at their free ends, whilst the radial filaments in the perch do not immediately proceed from the cones, but are connected thereto by the intercalation of nucleated corpuscles (Zapfenkörner) placed at the upper pole of the cones. Whatever interpretation be eventually put upon the phenomena I have here recorded, those members of the Brighton Microscopical Society who were present on the occasion to which I have referred, will bear me out as to the occurrence of many of the changes above described, and I consider myself particularly fortunate in having been assisted in the determination of these facts by Dr. William Addison, F.R.S., F.L.S., Mr. J. Jardine Murray, F.R.C.S.E., Dr. Hallifax, Mr. D'Alquin, and especially also by Mr. Hennah, whose skilful manipulations are so well known to microscopists. Let me add, in conclusion, that after a due consideration of the foregoing particulars, associated with many data previously known to science, as well as other personal experiences not here recorded, I think the following deductions may be legitimately drawn and placed on record.

1. That the occurrence of opaque, white, stellate, circular patches in the sclerotic of the cod is almost invariable in old and tolerably full-grown examples of this fish, and that their contents resemble the so-called pseudo-naviculæ of *Gregarinæ*. They are, in point of fact, tailless *Psorospermiæ*, and therefore, also perhaps, non-ciliated zoospoores, whose genetic relations with *Gregarinæ* are not clearly made out. In my opinion the *Psorospermiæ* are referable to the lowest forms of vegetable life, and should be transferred from the *Protozoa* to the *Chlorospores*, or *Confervoids;* or, to speak more precisely, they should come somewhere between the *Palmellaceæ* and *Desmidiaceæ*.

2. The so-called choroid gland of the cod and other osseous fishes, is neither glandular, muscular, nor erectile, but is a specialized vascular plexus of capillaries. It is in no way connected with the adaptation of the humours of the eye to varying focal distances, but is probably intended to modify the circulation of the blood in a situation where, from the proximity of the heart, a strong impulse would interfere with the reflection of a correct image from the choroid. In cartilaginous

fishes, where no choroid gland exists, other anatomical arrangements appear to subserve the same purpose.

3. The phenomena above described in connection with the twin-cones of the cod show that the baccillary prolongations (Zapfenstäbchen) are not persistently formed appendages, as hitherto supposed, but they are filaments capable of protrusion from the cones on the application of certain stimuli. The cones themselves are to be regarded as special tactile bodies, destined to receive and convey to the true nervous elements of the retina, pencils of light reflected from the choroid. They are analogous, therefore, to the ordinary Pacinian corpuscles of the skin, which they resemble in many respects, and each cone may not inaptly be compared, in a functional sense, to a single ocellus in the compound eye of an insect. The vertebrate ocelli, so to speak, are arranged on a convex expansion of the optic nerve, with their visual planes directed inwards, whilst in the compound eye of invertebrates the ocelli are directed outwards.

THE VOYAGE OF AGUIRRE IN SEARCH OF EL DORADO.*

No picture of the sixteenth century would be complete unless it recorded the remarkable adventures of the Spaniards in search of the marvellous treasures which the American Continent was presumed to contain. Nowhere else do we find such a strange combination of credulity, superstition, avarice, chivalry, and ruffianism, as was exhibited by the various bands of marauders who went in search of the famous El Dorado, the imaginary region of exhaustless wealth.

After plundering the flourishing states of Mexico, Bogotá, and Peru, the madness for gain was increased, and instead of availing themselves of the boundless opportunities for the exercise of industry, which the new countries presented, the attention of the adventurers was turned to the interior of the continent, where golden cities were supposed to be concealed by the vast primeval forests which separated them from the common world. Among the local facts and customs which served as the basis for the wildest fables, it appears that the chief of Guatavitá made a solemn sacrifice once a year, and to

* *The Expedition of Pedro de Ursua and Lope de Aguirre in Search of El Dorado and Omagua*, in 1560—1, translated from Fray Pedro Simon's *Sixth Historical Notice of the Conquest of Tierra Firme*, by Wm. Bollaert, Esq., F.R.G.S., Corresponding Member of the University of Chile, Member of the Ethnological Society of New York, with an Introduction, by Clements R. Markham, Esq. London: printed for the Hakluyt Society.

fit himself for this important ceremony, he smeared his body with turpentine, and then rolled in gold dust, which caused the precious metal to adhere. In this condition he went upon a raft, in company with his chief nobles, and when the centre of a lake (Guatavitá) was reached, he made an offering of precious stones, and then jumped in to bathe. These proceedings were supposed to propitiate the aquatic deity of the place—the miraculous Cacica—who, having been thrown into the lake by a quarrelsome husband, was believed to dwell in a delicious retreat beneath its waters, in company with her daughter, whose favour the worshipper likewise invoked. In his learned work* on the antiquities of these countries, Mr. Bollaert informs us that "the principal places of adoration of the Chibchas were lakes, where they could make offerings of the most precious things, without fear of others profiting by them; for although they had confidence in their priests, and knew that they carefully buried the offerings in the vases destined to receive them, they were naturally more secure when they threw those objects themselves into lakes and rivers." The same writer tells us that the Geques, or Chibcha priests, were taught, during an initiation of twelve years, the computation of time and other traditional learning, which has been lost through the savage persecutions to which the bigoted Spaniards exposed the ministers of a superstition scarcely grosser than their own most deplorably perverted faith.

The origin of Mexican civilization will remain a puzzle for future ethnologists and antiquarians to unriddle, if they can; but in any speculations of this nature we must not be too easily induced by analogies to imagine that it was copied from other countries, as large allowance should be made for the operation of the law, under which, similarity of condition, tends to produce similarity of habits and opinions amongst races the most remote. Whatever may have been the early history of the people of Mexico, Bogotá, and Peru, they were found by the Spaniards in a state of society peculiarly calculated to stimulate their adventurous and avaricious propensities. The love of the marvellous, the desire to acquire wealth without the monotony of daily toil, together with boundless opportunities for personal distinction, all conspired to make the New World a favourite field for the exertion of restless spirits, and as its unfortunate inhabitants were heathens who resisted conversion, they might be robbed and murdered with the sanction of the Church. It was while these feelings were in their full strength that a Captain Pedro de Ursua, having been duly authorized by the powers of

* *Antiquarian, Ethnological, and other Researches in New Granada, Ecuador, Peru, and Chile, with Observations on the Pre-Incarial, Incarial, and other Monuments of Peruvian Nations*, by Wm. Bollaert, F.R.G.S. Trübner and Co.

the State, left Peru in search of certain countries, of which some Brazilian Indians had given a tempting description. After various difficulties and dangers, he made his way from Lima to a spot on the Amazon, in the interior of the continent, and rather less than half way towards the mouth of the gigantic river. The young knight, who was accompanied by a beautiful lady, the Doña Inez de Atienza, appears to have conducted his operations with considerable skill. He was a brave and accomplished soldier, but far too mild a commander for the turbulent marauders he had undertaken to lead. Such an expedition, in imperfect vessels, through an unknown country, could not be devoid of hardships, and as these were encountered, mutinous feelings, which had manifested themselves from the beginning, gathered increasing strength, until, on the 1st January, 1561, Ursua and his lieutenant were murdered, and one Don Fernando chosen as chief, while Aguirre was appointed "master of the camp." The new commander commenced his administration by calling a council, at which he proposed that all the officers should sign a document incriminating Ursua, and representing his assassination as a necessary act done in a spirit of loyal obedience to the King of Spain. By this trick, Fernando hoped to secure the favour of his sovereign as well as the profit of the anticipated discovery of the golden lands. Such a scheme might have succeeded with villains of the common sort, but the new camp master was a monster of a different stamp, and with the reckless daring of unblushing infamy, he signed himself the "Traitor Aguirre," and ridiculed the idea of employing deceit. From this moment he became the real leader of the expedition, and from time to time he kept up his *prestige* by a series of revolting murders and atrocities, which are very wearisome and disgusting reading in Father Simon's memoirs. Of course, Don Fernando did not escape from so dangerous a rival, and not even the beauty and sorrows of Doña Inez could preserve her life from this tiger chief. As a career of crime, that of Aguirre is most extraordinary, and it gives us no little insight into the character of the kind of persons who joined these adventures, to find that such a mad monster should have been able to retain his command. It is not our intention to follow his guilty steps; but it may afford some consolation to know that both he and his principal followers were finally disposed of in pursuance of the decrees of the King of Spain.

In a geographical point of view, the voyage of Aguirre has been invested with a fictitious importance by a theory which Mr. Markham espouses, and according to which he managed to pass from the Amazon to the Orinoco by way of the Rio Negro and the Cassiquiare Canal. Humboldt, who was acquainted with Simon's book, assigned to him a much more probable route,

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and supposes that he simply sailed down the Amazon, and then followed the line of the coast to the N.-W. till he reached Margarita, a little beyond Trinidad. Mr. Markham goes so far as to represent the Rio Negro track as the one which is sanctioned by Simon's narrative. Such a conclusion does not, however, seem warranted by the text, and it would have been more prudent, if Mr. Markham had avoided committing himself to what will probably prove an untenable theory, not sustained by a single indubitable fact. We do not discover in Mr. Bollaert's portion of the volume before us any indications of his supporting the more improbable view.

THE NEW TEMPLE OF INDUSTRY.

BY JOHN HOLLINGSHEAD.

If the building raised at South Kensington for the Second Great International Exhibition had not been practically the work of a not over modest department of the State, it is possible that it might have been quietly accepted as one of those costly makeshifts for which, as a nation, we are rather famous. A few keen critics would doubtless have questioned the claim of its designer to be immortalized as a constructive genius; a few imaginative architects, who love to turn all our black riverside wharves into marble palaces on paper, and dream of reviving the glories of ancient Babylon at Holborn Hill, would have shown us pretty fancy chromo-lithographs of what it might have been, while the majority of practical exhibitors would have been satisfied with it as a shed that had the merit of being water-tight and sun-proof.

The building designed by Captain Fowke, however, can claim no pity on account of its parentage. It springs from the very centre of a school which aspires to teach the true principles of designing art to an ignorant and benighted country. From the days when Marlborough House schoolmasters lectured us upon our barbarously-coloured carpets, designed shirts, and shaped wine-glasses, to this present period, when the South Kensington Museum gets two hundred thousand pounds at a time from a not very flourishing exchequer to enable it to teach its doctrines, we have been loudly told where to go to if we want to improve our taste. We have been carefully directed to the one existing college whose professors believe they possess the only true eye for harmony of form and colour, and whose missionaries, duly primed at head-quarters, are actively teaching South Kensington art throughout the country in local

schools of design. This is not an organization to be treated tenderly because of its weakness or retiring disposition, and what it builds must be taken as the realization of what it teaches. The structure prepared for the forthcoming International Exhibition is not so much the production of one man as of a clique, a school, and a system; and it affords us but a poor prospect of getting educational value for our money.

The first view of the building, approaching it from the Brompton Road, is disappointing and depressing. Never, perhaps, was so much thoroughly commonplace bulk put upon a given quantity of earth at one time. The factory-looking clerestory windows of the eastern transepts have an appearance of unutterable meanness; the long, dull line of the Cromwell Road, or southern front, overshadowed as it is by a row of unlet stuccoed mansions, looks like an ordinary carriage repository. The eastern dome, the first object prominently seen from this point, looks like a huge balloon that has fallen amongst the trees of the "Boiler" gardens; and the entrance under this disproportionate cupola is built much in the bygone bare style of a country dissenting chapel. A whole chapter might be written about these huge, misplaced domes, which have sucked up sixty thousand pounds sterling, or nearly one-third of the money guaranteed at the outset for the cost of the building. The lines of the sash-bars do not correspond in their curves with the iron ribs, and the result is that the panes of glass appear to be broken through by the iron-work towards the apex. The domes, though built of the lightest material, have a solid, earthy, heavy effect, because of their size and the lowness of their elevation. They are the largest structures of the kind ever executed, being one hundred and sixty feet in external diameter. The dome of St. Peter's is one hundred and fifty-seven feet and a half in diameter, and that of St. Paul's one hundred and twelve feet; so that, putting it arithmetically, Captain Fowke is a greater architect than either Bramanti, Michael Angelo, or Wren. Fortunately for the reputation of the old designers, the cross of St. Peter's stands four hundred and thirty-four feet, and that of St Paul's three hundred and forty feet above the pavement; while the gilded finials of Captain Fowke's structure are only two hundred and sixty feet above the ground. The domes of the two great cathedrals press upon buildings whose proportions are able to bear them without apparent effort; but Captain Fowke's swollen cupolas seem to crush the slight wooden framework on which they appear to stand. The South Kensington architect has certainly broken the flat monotony of his eastern and western fronts by these hollow mockeries, but at a cost of life and money far beyond what the effect is worth. The southern front gets

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no pictorial advantage from these overgrown monsters, being too far removed from them; and this is, oddly enough, alluded to as a merit in the general design. A great central dome over the southern courts (which will certainly never now be built) was intended to relieve the flatness of the southern front, and therefore the effect of the two existing domes in combination is confined to the Horticultural Gardens. As these grounds are now little more than a back garden to the Exhibition, it is only fair that they should have some compensating prospects, and from no point can Captain Fowke's building be seen in a more favourable light. Even here the disproportion of the domes still stands prominently forth, and they must be classed as twin monsters with the two water-towers at Sydenham.

Inside the building, the same harmony of proportion is felt to be sadly wanting, with the single exception of the British and foreign picture-galleries. The southern courts—called the open or glass courts—are light and spacious; but from the cramped height of the side-walls they have a depressing appearance of flatness. In design they are nothing more than a repetition of the Birmingham Railway Station, with this difference, that the latter has a noble span four times as great as that of these courts. The nave, which divides the building into two unequal halves lengthways, runs from one dome to the other; and its style, when we look at the meanly-glazed, commonplace, workshop clerestory windows, can hardly be called by any other name than factory-Gothic. The transepts, which run along the whole length of the eastern and western fronts (being intersected, of course, by the dome columns), are designed in the same style, and are surrounded, like the nave, with broad galleries. The spaces under these galleries must be more or less dark, as the flooring above is necessarily laid down dust-tight. The northern courts—a smaller repetition of the southern open or glass courts—are shut in by the brick wall of the refreshment-rooms, and as several windows and doors have been knocked in this wall to light and give access to the premises taken at a heavy rental by the food contractors, the eye is offended by what looks like a row of common irregularly-built houses. One or two of the staircases leading up to the galleries are also out of keeping with the rest of the building, having balustrades such as are generally found in small villas at Dalston. The two annexes—western and eastern —which sprout out from the main building, running along the sides of the Horticultural Gardens towards the Kensington Road, are lightly and inexpensively built, and having no avowed pretensions to architectural effect, promise to be the most pleasing parts of the structure.

The main picture-galleries, before alluded to, which occupy

the upper part of the southern, or Cromwell Road front, are substantially built, as in all probability they will become the property of the Society of Arts. The proportions here are noble and harmonious, and the plan of lighting from the top gives large wall-space, and a light free from glitter. It is upon these galleries, and the other "permanent portions" of the building, that the Commissioners are bound to spend fifty thousand pounds in architectural improvements, under contract with their landlords, the Commissioners of the former Exhibition. Twenty thousand pounds of this amount are already expended, and the outlay of the other thirty thousand is made contingent on the realization of a surplus.

The decoration of the building was taken out of the hands of the South Kensington art teachers, and given to Mr. Crace. In the nave the roof is coloured a warm grey, with upright scroll ornaments in maroon red, rising from the sides to the apex of the roof, the ridge of which is strongly defined by a chevrony in black and white. The main arches are coloured a warm brown, with panellings of blue and red, relieved with light lines and ornaments, and separated by medallions of black, on which are gold stars. On the crown of each arch are inscribed the names of the principal countries and towns contributing to the Exhibition. To avoid the succession of repeated lines of the same colour, variety is produced by alternating the colourings. The edges of the arched ribs, which are in three thicknesses, are defined by springs of black and white in the outer, and red in the centre thickness. The iron columns supporting the roof are painted a pale bronze colour, relieved with light coloured vertical lines, and having the capitals painted red and blue alternately, the raised ornaments being richly gilt. The iron ornamental gallery railings are also painted bronze, relieved with gilding. The two domes are decorated in a very effective manner. The twelve main ribs are painted red and gold, bordered with black and white, and relieved with gilt stars on small lozenges of blue. The top centres of the domes are painted blue, with gold rays, and are bordered with red and gold. The broad frieze running round the springing is painted blue, with an inscription in bold gold letters, and the cornice above is principally in red and gold colour. The walls above the arches under the frieze are richly ornamented in red panelling. In the four smaller compartments are Europe, Asia, Africa, and America; and in the spandrils of the large arches are medallions containing figures representing Arts, Sciences, and Manufactures. The walls at the ends of the nave and transepts are also richly ornamented and inscribed with appropriate legends.

The picture-galleries have their walls painted a sage green

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as a background for the pictures, and the cove is tinted to correspond, the cornices and soffits being vellum-colour, relieved with maroon lines and ornaments. The wall round the arches is also ornamented, but the general decoration of these galleries was obliged to be curtailed, from the necessity of their being used for the arrangement of the pictures.

The Commissioners for the Exhibition of 1851, as before stated, are the legal proprietors of the site on which this building is raised—the ground having been bought out of the surplus (about one hundred and eighty-six thousand pounds) arising from the first Great International Exhibition. The investment of that sum in South Kensington land has proved so fortunate, that the old Commissioners, by making roads, letting ground on building leases, and their arrangement with the Horticultural Society, must certainly have doubled their capital.

To secure the greater portion of this remaining site for a third proposed Exhibition in 1872, they have agreed to reserve about sixteen acres of it for that purpose on receiving ten thousand pounds by way of ground-rent. It is already agreed that a lease shall be granted to the Society of Arts of the central portion of the picture-gallery, one acre in extent, along the Cromwell Road, for ninety-nine years, on condition that ground-rent to the amount of two hundred and forty pounds per annum be paid to them, and that the building be given up unreservedly for the use of the Exhibition in 1872.

The work of building this new temple of industry was given to Messrs. Kelk and Lucas, under an arrangement with the Commissioners of 1862 that is very like a partnership. The whole responsibility for the execution of the works rested with the contractors, and the amount they are to receive is contingent on the receipts of the Exhibition. The Commissioners have the option of purchasing the building out and out, or of merely paying for the use of it. For the rent of the building a sum of two hundred thousand pounds is guaranteed absolutely; if the receipts exceed four hundred thousand pounds, the contractors are to be paid one hundred thousand pounds more for rent, and if the sum is fully paid, then the centre acre of the great picture-galleries is to be left as the property of the Society of Arts. The contractors are also bound, if required, to sell the whole for a further sum of one hundred and thirty thousand pounds, thus making its total cost four hundred and thirty thousand pounds. Captain Fowke's original design, with the great hall and central dome, was estimated to cost five hundred and ninety thousand pounds. This hall was to have been placed immediately behind the middle entrance of the south front, and was to have been five hundred feet long, two

hundred and fifty feet wide, and two hundred and ten feet high.

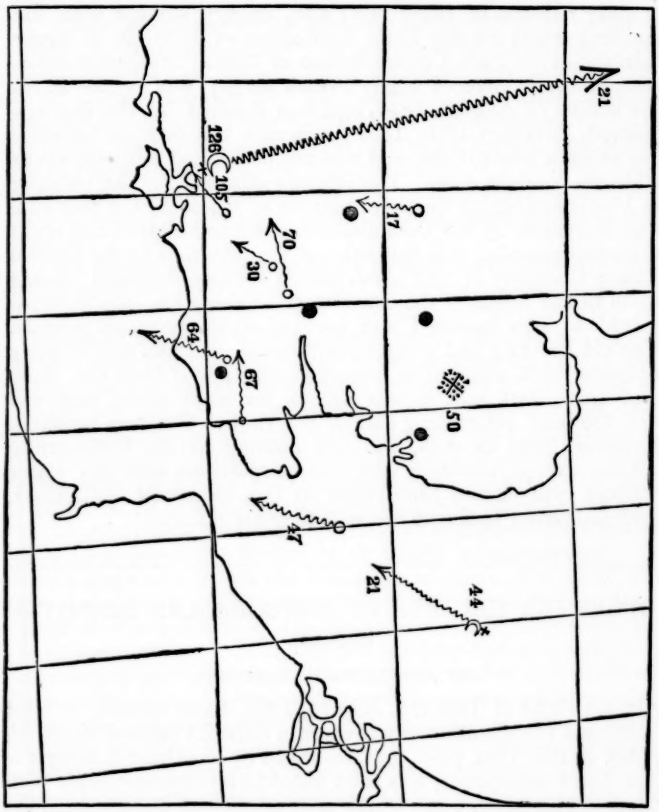
The laying out of the works was commenced on the 9th of March, 1861. About two weeks were occupied in making the measurements, and the building was begun at the commencement of April. It covers about twenty-four acres and a half or sixty millions of cubic feet; and, though smaller than the building raised for the Paris Exhibition of 1855, it is larger than the Hyde Park Crystal Palace of 1851. The latter structure, however, covered nearly twenty acres; was begun about the middle of August, 1850, and was finished by the day appointed, February 12th, 1851; whereas the present building has taken a year to raise, and was not completed until six weeks after the contract date. The original contract for the building in 1851 fixed eighty thousand pounds as the cost; but this sum was increased by the Commissioners to one hundred and eight thousand pounds, and the sale of the materials to the Crystal Palace Company of Sydenham placed seventy thousand pounds more in the hands of the contractors—raising the sum they received to one hundred and seventy-eight thousand pounds. The old building had many imperfections, and was not, in many respects, well adapted to preserve costly goods from sun, dust, and rain; but still it was valued for itself alone, and was not the least interesting part of the show. The new building, however, large as it is, will add nothing to the forthcoming display except heaviness and bad proportions, and the wisest visitors will devote themselves to the industrial collections, and endeavour to forget the roof they are under.

OBSERVED HEIGHTS OF METEORS AND SHOOTING STARS.

BY ALEXANDER S. HERSCHEL.

On the night of Tuesday, July 16, 1861, three meteors at least attracted the attention of travellers in different parts of England. That of 10h. 15m. p.m., first described by the Duke of Argyle in the *Times* newspaper, was soon found to be irreconcileable with that of 11h. 32m., p.m., which took a southward course, and the discussion elicited an account of a third, which was seen at Bristol to move from north-west down to the west at half-past nine of the same evening. The accounts collected of the two former meteors showed that of 10.15 p.m. to have moved from 305 miles over Liege in Belgium to 35 miles over the North Sea, 70 miles east of the town of Morpeth, in Northumberland. This we gather from accounts at London, where it disappeared due

north at an altitude given at Tunbridge Wells as 8° or 10°, while from Tunbridge Wells it was seen to commence at an altitude of 40° due east. At Darlington, in Yorkshire, the commencement was due south-east at altitude 30°, the disappearance was north-east by east altitude 25°. The intersection



of these lines of sight are accurate at the above points, and the prodigious flight of 350 miles appears to have been performed in 10 or 11 seconds, or a very little less. The inclination is 31° to the horizon towards 37° west of north. An adhering tail, but fugitive like the meteor, pursued the nucleus, which

was almost globular and 5′ or 6′ in diameter, and shed at Furness Abbey a light equal to the crescent moon. This tail was 2° or 2½° in length, and colourless like the meteor. No change appeared throughout the flight until before disappearance a companion was seen to pursue it closely. Both then vanished together abruptly.

The second meteor appeared to move at London from 15° S. of the zenith towards a point of the horizon 54° W. of S. At Liverpool, it flew from alt. 40° in the S.E. by E. to a few degrees above the horizon S. by W. We infer from these data (slightly modified by other observations), a flight of 300 miles from 195 miles above the Straits of Dover by North Foreland, to 60 or 70 miles above the English Channel, 60 miles S. of Plymouth. This course passes at a height of 150 miles over the Isle of Wight, at which point an enduring tail began to be given off, and continued to be developed to the end of its course. After the dispersion of the nucleus, this tail drifted eastward in the direction of the rising wind at a speed of 1000 feet a second.

The course of 270 horizontal and 130 vertical miles, is inclined 27° to the horizon towards 57° W. of S., and the velocity of the meteor was 60 miles a second, while that of the former was only 30.

Encouraged by the success of these determinations, a campaign was organized for the observation of the shower of meteors on the coming 10th of August, in which Mr. Glaisher, and numerous other observers, professional and amateur, promised their assistance for a single hour on every night.

The first result of this combination was a letter from Mr. J. Baxendell, in Manchester, describing a brilliant meteor at 11h. 21m. p.m., I.M.T. of the 6th of August, having two maxima of brightness in a short crooked path of only 3½°, near the star ε Capricorni, in which it moved for more than two seconds of time. A later communication, from Messrs. J. Townsend and T. Crumplen, contained the following observation, of the same date, in Trafalgar Square. The time differs only one minute from that of Mr. Baxendell's observation:—"A meteor brighter than that of July 16th shot from near α Coronæ to χ Ursæ Majoris. It appeared to be extinguished, and then suddenly rekindled. Duration 6 sec.; tail 2 sec."

Taking half-way between the two last observed places as a trustworthy point in the meteor course as seen from London, this line of sight is found to pass within seven miles of that from Manchester to the centre of the meteor (as there observed), at 80 miles high, half-way between Leicester and Birmingham. Judging from the foreshortening of 48°, as seen from London, to 3½° as seen from Manchester, we must accept the course to

have been directed through this point almost direct upon Manchester, and hence we obtain by the London observation a flight of 176 miles in five or six seconds; from 126 miles over Winchester to 21 miles over the north point of Staffordshire, at an inclination of 37° to the horizon, from 16° E. of S.; and in this course of 105 vertical and 140 horizontal miles, the flame was kindled into brilliance two distinct and separate times.

On the 8th of August the Rev. James Challis saw at Cambridge a second magnitude star shoot downwards at alt. 40°, 11° E. of S., rapidly at an inclination of 30° to the right from horizontal. While at Greenwich, within 20 sec. of the same time, Messrs. W. C. Nash and J. Howe saw a second magnitude star pass very rapidly from α Cygni to Delphinus, leaving a faint tail.

Placing the Greenwich centre at q Vulpeculæ, we have a line of sight which intersects the Cambridge line of sight accurately at 67 miles over Sandhurst, in Kent, through which point this meteor was directed upon Alton, in Hampshire, at 46° from horizontal towards 3° S. of W. The meteor may have been 20 miles long, with a speed of 30 or 40 miles a second.

Two minutes later a flash was seen at Cambridge Observatory by Mr. A. Bowden, altitude 61°, 73° E. from S. No path could be perceived in it. Dr. Lee's party of observers at Aylesbury beheld it near ω Andromedæ, but from the absence of any bright stars for reference near the foot of Andromedæ, we must not trust this observation beyond a certain point. It was recorded by Mr. S. Horton "Like a gas flame suddenly lighted and then put out. Very curious." These two lines of sight are 12 miles asunder, at 50 miles above the neighbourhood of Bury St. Edmunds, and as the parallax is 34°, we must suppose this singular meteor to have had no perceptible path, but to have been indeed, as described at both stations, a momentary flash equal to the illumination of not one, but of 500 or 600 gas-lights at once; for it is recorded equal to a second magnitude star at Cambridge, and there its distance was 54 miles.

The next accordances were on the 10th, when two third magnitude meteors appeared at Greenwich, one below the other, whose paths at Cranford were coincident. The apparitions were undoubtedly the same, but the observations are somewhat vague. The lines of sight for one meteor pass 15 miles apart, at 30 miles over Guildford, in Surrey. Those for the second are 19 miles apart, 105 miles over Bishop Waltham, in Dorsetshire; both appear to have been nearly vertical.

Three minutes after this remarkable pair, a more brilliant meteor shot at Cranford to the right in the square of Pegasus.

It was observed at Greenwich to commence over α Andromedæ. The parallax of 7°, obtained from the records, give a height of 47 miles over the English Channel, 20 miles east of the North Foreland. The meteor was conformable to β Camelopardalis, and we may infer for it a course of 35 to 40 miles, performed in little more than one second of time, at an inclination of 38° to the horizon towards 42° W. of S.

Five minutes later than this a second magnitude meteor, with a tail, was observed by Mr. Nash to fall from γ Ursæ Majoris towards the horizon, while at Cambridge two meteors with centres coincident succeeded each other almost immediately—one of third magnitude, the second of first magnitude, leaving a tail. The second was seen, by the Rev. James Challis, to shoot to the left at 45° to the horizon, at altitude 20°, 13° S. of W. A line of sight at Greenwich, half-way between γ Ursæ and the horizon, intersects this Cambridge line of sight accurately at 17 miles over Buckingham, and assuming it to have been slightly inclined to the left at Greenwich, we infer it to have flown some 20 miles at 40° to the horizontal from N. to S., from a height of 24 miles to perhaps only seven above the earth. This is the lowest meteor which the observations render in any degree probable.

About a quarter of an hour after this two small meteors appeared, to Messrs. W. C. Nash and J. Howe, to succeed each other rapidly from α Cygni—one to α Lyræ, the other towards Delphinus. Within 10 seconds of the time of the first, a meteor is recorded at Cambridge, by the Rev. James Challis, of third magnitude, altitude 46°, 26° W. of S., moving downwards to the right at 30° to the horizontal. A line of sight, directed from Greenwich to ι Lyræ 3-5ths of the way from α Cygni to α Lyræ, intersects a line of sight from Cambridge, altitude 48°, 21° W. of South, accurately at 70 miles over Leatherhead. From this point the meteor was directed to the town of Andover, at 54° to the horizontal, towards 20° S. of W., in a course perpendicular to the town of Cambridge, where, at a distance of 94 miles, every 5 miles of flight would subtend 3° of arc. This meteor closes the list among the accordances of the 10th of August. It was probably from 20 to 25 miles in length. At 300 yards' distance it would have shed the light of the full moon, and it burned with the brilliance of 400 ordinary gas-lights.

On August the 11th fewer accordances were obtained. Sixty observations at Hawkhurst, and nearly half as many at the contiguous station of Flimwell, are so strangely discordant that the wonder is how so many meteors should have been inserted so entirely disagreeing in time and place: the only one accordance is too vague to yield a useful parallax. This was

dull red, and tailless during the last third part of its course, in strong contrast to the previous two-thirds, where the meteor was brilliant blue, and emitted a lengthy enduring train. It was not noticed at any other station, and was possibly of low altitude like that surmised over Buckingham.

Within five minutes from this time, however, a beautiful white meteor shot 8° very slowly in the E. from Hawkhurst. The tail was the most enduring of the evening (7 seconds). Duration $1\frac{1}{2}$ secs.; shot to clock hour IV$\frac{1}{2}$, at altitude 16°, 33° N. of E.; a careful observation.

At Ipswich the same meteor was seen to terminate at γ Pegasi, inclined 40° to the horizontal. We infer from this a path of 36 miles, from 44 to 21 miles above the English Channel, 70 miles E. of Ipswich, at an inclination of 42° to the horizon towards 20° W. of S.

Seven minutes later a second bright meteor was at Ipswich observed to pass down the centre of the Milky Way, which was vertical at Hawkhurst. It was of first magnitude and left a tail, and appears to have been 64 miles over Hailsham, in Sussex, performing 25 miles in half a second, almost horizontally towards 12° W. of S.

A map of these accordances is annexed for illustration, and it is particularly desirable to make these observations on the nights when meteors are most abundant, as we may hope to trace on quiet nights an outline to the regions where these fugitive particles become incandescent more surely than on separate nights, and in separate conditions of the atmosphere. On the 28th of January, 1862, a shooting star was very accurately observed, between London and Aylesbury, to traverse a horizontal distance of 60 miles, with a uniform speed of 40 miles a second, horizontally from 44 miles over Melton Mowbray, in Leicestershire, to 47 miles over Macclesfield, in Derbyshire. It shone throughout as a first magnitude star, without change of brightness; the course appears only 12° in length at London, and 20° in length at Aylesbury, and it is difficult to account for these decided points of kindling and extinction upon a horizontal course of a projectile, if we do not admit a column, or wave, of the atmosphere to be here singularly uplifted; and the rapid motion of the tail in the meteor of July 16th seems to point equally to violent commotions upon the upper surface of the atmosphere.

THE FISH WORLD AT HOME.*

EXCEPT as a race of creatures which supply a peculiar kind of food, the fish world is less popularly known than any other conspicuous division of the animal kingdom. Indeed, unless we consider it in a culinary sense, it is easier to like anything better than a fish; for although the forms of many species are strange and wonderful, though they are decorated with colours as varied and as brilliant as those of birds, the great difficulty of studying their habits diminishes the interest which their peculiar or splendid appearance might otherwise induce us to feel. Our affection for animals is strongly influenced by their agreeableness or unpleasantness to the sense of touch; and even when prudence forbids such tactile experiments, we look at the lion or bear as creatures we should have no objection to fondle, if their moral character was of a more amiable kind. When we pass from the warm-blooded mammalia to the important group of reptiles, we are conscious of a great diminution of sympathy, and though a few people make pets of snakes and tortoises, while some of the graceful lizards of warm countries are welcomed in the domestic circle, there is on the whole too great a gulf between the human and the reptile life for us to enter readily into their mode of being. This discrepancy becomes still more striking when we descend to the fish, the inhabitants of an alien element, and the dwellers under conditions by no means easy for us to ascertain. It is true that from an early antiquity men have half domesticated certain kinds in ponds, and before the aquarium assumed its present elegant and instructive shape, many generations had seen gold and silver fish swimming round the old-fashioned globes, with a monotony of motion only varied by the occasional occurrence of illness or death. But these experiments and observations added very little to our substantial knowledge of fishy life, and when the naturalist obtained his specimens, he usually studied them as dead organisms and not as fellow-inhabitants of this living world. These causes may tend to make icthyology less often a favourite study than other branches of natural history, but very little attention is required to invest it with an interest of its own. Regarded geologically, the fish present us with the oldest distinctly known group of vertebrate animals. Older, or as old, may have existed; but if land vertebrata should be proved to have been contemporaries with the earliest fish, the latter would still appear to have

* *A History of Fishes of the British Islands.* By Jonathan Couch, F.R.S. Vol. i., containing fifty-seven coloured plates from drawings by the Author Groombridge and Sons, 1862.

played a very important part among the pristine* inhabitants of the globe. In our own times the waters cover two-thirds of the earth, and within certain limits they are thickly peopled by the finny race. The subaqueous land is as diversified as the subaërial, and if we could roam over the sea-bottom as we do over the dry surface, we should find its varieties of contour as strongly marked. In some spots we should discover sedimentary plains, in others elevated table-lands and lofty mountain chains, while the vegetation would be plentiful, scarce, or absent, according to laws analogous to those which affect terrestrial plants. In some situations, where the water is shallow and the soil appropriate, we should come upon green meadows of the common *Zostera marina;* on rocks in deeper water we should find groves and forests of the oar-weed (*laminaria*), and other tree-like algæ; and if in our own climate these seldom exceeded twelve or fourteen feet in length, we need only go to the coast of North America to find a tangle, named *nereocystis*, with stems three hundred feet long, and floats like huge casks, crowned by tufts of prodigious leaves, among which the sea-otter makes his lair. On dry land the most numerous population is seated at, or near, the sea-level, or at what we may call the bottom of the aërial ocean which enfolds our globe; except on the Mexican plateaux, animal forms become scarce after an elevation of a few thousand feet, while extreme mountain heights are solitudes scarcely broken by the sound or sight of life. In the watery regions some differences occur. There, the mountains, instead of being deserts, present conditions which offer some analogies to the sea-level surface of the earth. Light is abundant in such situations, and the moving waves carry to the limited depth a more ample supply of air. Here then life abounds, and it is the lowest valleys and plains of the ocean beds, which correspond with the subaërial mountain-peaks, in affording a very restricted accommodation for living beings. Recent discoveries in deep sea dredging modify old statements about the total absence of life in the dark and profound recesses of the sea; but at any rate, so far as the higher forms are concerned, dense populations occur only at moderate depths.

The subaqueous scenery of our own shores exhibits on a limited scale the varied aspects to which allusion has been made; but it nowhere sinks to remarkable depths. In the North Sea, between us and Norway, 140 fathoms is said to

* "No vertebrate animal higher in the scale than fishes is as yet certainly known to have been found in any rock of Devonian age. In fact, until demonstrative stentigraphical evidence of the Devonian age of the red known Elgin beds is obtained, the bearing of the palæontological evidence against that conclusion is too strong to allow of its being entertained."—Professor Huxley, *Memoirs of Geological Survey, Decade* X.

be the extreme depression. The English Channel, east of Eddystone, is not more that 50 fathoms; but on the west coast of Ireland, Dr. Harvey tells us, a depth of 300 to 400 fathoms is soon attained. As a rule, the sea-bed, within a a moderate distance from the shore, partakes of the geological character of the formations on the coast; and if a fish swam from the granites and slates of Cornwall to the chalk of Sussex, he would find the peculiarities of the watery region changing very much like those on the land. Such, then, are a few particulars of the localities in which fish existence is carried on. As on dry land, the plants nourish certain kinds of animals, and the strong devour the weak according to the various methods of predaceous life; but there is this difference between terrestrial and marine vegetation, that the latter derives nearly all its nutriment from the fluid element, as its roots are, for the most part, only anchors and supports, and not also a machinery for the absorption of food. Thus the water, with the various saline, earthy, and other elements that it holds in solution, forms the foundation of the entire mass of existence whichit contains.

If we pass from the consideration of where the fish lives, to the inquiry of what the fish is, we find it to be, in the words of Dr. Grant,* "a cold-blooded, oviparous, branchiated animal, with one auricle and one ventricle of the heart, not undergoing metamorphosis, covered with scales, and having the arms and legs constructed as fins, for a permanent residence in the waters. The rudimentary lungs (air-bladders) are very rarely employed for breathing, generally for regulating their specific gravity. They mostly impregnate the ova externally, aud there is no amnion or allantois in the ovum." To this brief description some particulars must be added, for, in the words of Mr. Couch, "in a fish the whole mass of blood passes through the gills for the purpose of receiving the influence of the air contained in the water, without being again returned to the heart, until it has been carried to the other parts of the body."

The heart of a fish is thus devoted to the *respiratory* circulation. In the reptile, which stands in zoological rank higher than the fish, the heart has three cavities—a single ventricle, and two auricles; but breathing air direct, by means of lungs, and passing much of its time in torpor, or repose, it does not need that all its circulating fluid should be exposed to the respiratory process before traversing its body; and hence one portion of aërated blood from the lungs, is mingled with another portion of venous blood which has not passed through them, and this mixture is sent out by the single ven-

* *Tabular View of the Primary Divisions of the Animal Kingdom.*

tricle of its three-chambered heart. As energy of character and capacity for exertion are usually proportioned to the amount of heat which an animal evolves, we must expect that fishes, with a respiration rendered imperfect or slow, from the nature of the fluid in which they live, and with bodies whose internal temperature is lower than that of mammals or birds, would be, in many respects, sluggish creatures; and to a large extent they deserve this character; though the shark tribe exhibit activities very analogous to those of terrestrial beasts of prey. In Mr. Couch's valuable and interesting *History of the Fishes of the British Islands*, which follows a generally-recognized system, these voracious creatures are placed at the head of all the families of Fish. Together with the ray-fishes, they belong to the *Chondropterygious* order; and it is consolatory for those who are alarmed at such an awkward, jaw-breaking term, that a better-sounding and more popular word, "cartilaginous," will do just as well. The characteristic of the skeleton of these fishes is the absence of that quantity of mineral matter which gives rigidity to ordinary bones; but, as Professor Owen says, "I know not why a flexible vascular animal substance should be supposed to be raised in the histological scale because it has become impregnated by the abundant intussusception of earthy salts." The shark has, for a fish, a large brain, immense strength, and a capacity for prolonged exertion, which Mr. Couch traces to the highly-developed character of its muscles, which "bear a resemblance to those of quadrupeds." The eye of this tiger of the deep affords the quick vision required for its predacious life, and Mr. Couch thus explains its peculiar mechanism:—"On examining the cavity in which the eye of the shark revolves, we find that the globe, which is the immediate seat of the power of vision, is lifted from the bottom on which, in other animals besides this great family, it rolls, and is placed on a small table that itself forms the top of a slender pillar, the bottom of which is fixed on the bony circle of the common ocular cavity, or, more properly speaking, of the pillar itself, which leans a little forward that it may be accommodated to the most usual direction in which objects are viewed . . . . . The height of this ocular pillar has the additional advantage of allowing a greater length to the muscles which move the eye, and, by so doing, of providing for a more sudden as well as a more extensive action of the eyes in prowling for their prey."

The general form of the jaws of the shark is well known through specimens in museums, but to Mr. Couch must be assigned the merit of observations on the formation of the teeth, which appear to have been simultaneous with those made known by Mr. Owen, and which are thus described:—"In all fishes

the first step in the formation of teeth is the simple production of a soft vascular papilla, or pimple, from the free surface of the membrane of the jaw, near the mouth; but in the sharks and rays these papillæ do not proceed to sink into the substance of the gum, but become covered by caps of an opposite free fold of this membrane. These caps do not contract any organic connection with the papilliform matrix (and in the torpedo they are very loose), but as this is converted into the dental tissue, the tooth is gradually withdrawn (the points of the teeth at first lying flat downward, or in the direction toward the mouth) from the extraneous protecting cap, and as they become hard from being clothed with an enamelled surface, they assume the upright posture on the border of the jaw." The several rows of teeth are successively carried forward "by action in the membrane itself on which they rest, until being commonly broken or worn down by the violence to which they have been exposed, by the time they have reached the outer jaw, an exfoliation of the membrane itself has taken place, and they drop off by a natural process of exfoliation, to be succeeded by others, which are in their turn formed at the border of the jaw nearest the mouth, and pass upward and outward."

The greater number of sharks hatch their eggs in their own bodies, but the ground sharks deposit their ova in singular leathery bags, with long twisted strings at their corners, similar to those of the skates, which are common on every beach. The British sharks, which are most generally seen by sea-side visitors, are dog-fish of small dimensions; but many larger species frequent our shores, and Mr. Couch describes no less than seventeen which belong to us, as more or less regular inhabitants, and among them we find several quite worthy of their formidable fame. One magnificent species, and less ferocious than most of his brethren, performs a regular migration along the west coast of Ireland, and the western islands of Scotland, and is the profitable subject of periodical attack. This is the "basking shark," or sun-fish, so called from its habit of basking in the sunshine during calm, bright weather. It is killed with a harpoon, and valued on account of its liver, which weighs "two tons," and yields a large quantity of fine oil. Mr. Couch says this is the largest of all true fishes, and he gives a drawing of one captured in Cornwall, which measured thirty-one feet eight inches in length. The two most extraordinary-looking sharks are the "Thrasher," which is not "uncommon on the western and southern coasts of Britain in the summer," and the "Hammer-head," which is "a rare wanderer in our seas." The first is eleven or twelve feet long, and remarkable for the great length and strength of the upper division of its tail, while the second has a head extended

sideways like a hammer on its handle, with an eye at each end.

We may picture the sharks roving freely in search of their prey; and could we witness the daily life of the sea, we should find them as ferocious, and more ravenous, than the lions and tigers of the land. But if we surveyed the bottoms of smooth bays, we should be struck with the peculiar aspects, and large dimensions, of the family of skates. Although capable of vigorous motions, their usual habit is to lie flat, and as they are creatures of high organization, they require a breathing apparatus which can act powerfully in such a position. Accordingly, each side of the body of a skate is provided with four double gills, and one single gill; the entire gill system exhibiting one hundred and forty-four thousand folds, with an aggregate surface of fifteen square feet, the whole being covered by an elaborate network of minute vessels. If a great fish of the skate family is seen lying dead, as a huge lump, on the beach, it is difficult to form an idea of its behaviour in the water, when its swimming capacities are aroused, but a glance at the beautiful coloured plates in Mr. Couch's work, affords an easy insight into some of their habitudes and powers. One of the most striking of these pictorial illustrations, is the figure of the "Eagle Ray," in which the brilliance of the green eye, the wing-like character of the expanded fins, and the fierce flapping of the long whip-like tail, furnish a picture as wonderful as that of any monster of which mythology or fable tells.

Nor must we suppose that, if it were possible for us to take a journey through the watery regions of the fish world, that we should meet with no instances of constructive skill, or intimations of that maternal affection which reaches its full development among the mammalian tribes. There is, for example, a fish well known on all our coasts which makes a nest, and watches over the safety of its progeny until they are able to take care of themselves. This is the "Fifteen-spined Stickleback," or Sea-Adder, a creature about six inches long, of an elegant tapering form, and varying in colour, but figured by Mr. Couch as golden-yellow and brown. The nest-making capacities of this animal have only recently been ascertained. Something of the kind was previously suspected, and this led Mr. R. Q. Couch to prosecute his investigations, until he was happily rewarded by success. The places selected by the Sea-Adder for its nursery are harbours or recesses sheltered from the violence of the waves. The nests are formed by tying together tufts of seaweed and coralline with a thread secreted from the fish's own body, and which resembles elastic silk. In one instance, Mr. Couch found a nest as big as a man's fist attached to the separated strands of a rope which was hanging

in the water, and in this case the materials for the structure must have been carried about thirty feet. Mr. Couch observes on this interesting phenomenon, that the roe does not appear to be deposited all at once, that it is passed through the mass which forms the nest in various directions, and appears in little clumps in various stages of development. He adds—"They are watched over by the parent—in every case, I believe, by the male—who never quits his station; but an instance has occurred where two fishes have been engaged in attending one nest; and if the guardian is forced to retreat by the receding of the tide, he returns as soon as the way is open, and for three or four weeks continues his guard, until the young are able of themselves to take their chance in the broad expanse of the sea. So much is he intent on the principal objects of his solicitude, that at this time himself may be easily caught, but he resents every interference with his nest; and if the grains of ova be exposed to sight, as was done by way of trial, the breach was immediately repaired by the labour of dragging the materials into a position by which they were again concealed and protected."

Referring those who desire to gain a knowledge of the various genera and species of British fishes to Mr. Couch's agreeable and richly-illustrated pages, we may advert to the labours of Dr. Dufossé in rescuing the piscine world from the wholesale charges of dumbness that have been brought against it, and showing the foundation of ancient stories that were too often disbelieved. His researches have been chiefly confined to the gurnards and dories, which he tells us are able to utter prolonged and varied notes by means of vibrations in the muscles of their swimming bladder, and if all that the learned doctor tells us be true, the fish family may have oral discussions and concerts of their own, the performers being able to execute passages which an opera *prima donna* would be astonished to hear. This certainly opens a new view of submarine society. It may, after all, be diversified by other incidents, besides devouring and being devoured; fishes may exchange such thoughts and sentiments as their feeble brains may form, and their existence be rather more than

> "A cold, sweet, silver life, wrapp'd in round waves,
> Quickened with touches of transporting fear."

THE PLANETS OF THE MONTH.

BY THE REV. T. W. WEBB, F.R.A.S.

MERCURY may be seen in the morning, at the beginning of the month; but a more favourable opportunity will occur in May.

Venus is now transferred to the other side of the Sun, and, rising before him, she will be only watched by those few who pursue their studies

"Under the opening eyelids of the morn."

They, however, will see her to advantage, as she has already attained a considerable elongation from the Sun. Her greatest brilliancy takes place on April 2, when, as well as for some time afterwards, she may be followed, not only with the telescope, but even with the naked eye, even till noon-day: and an exquisitely beautiful object she is, when her glare is thus subdued by an illuminated background. An equatorial telescope of course renders it perfectly easy to find her at any time; but those who do not possess such an instrument will have little difficulty in keeping her in view in a clear day, if she is first found before sunrise, and subsequently watched from time to time, without allowing too great an interval between the observations. The epoch of greatest brightness depends upon two continually varying conditions—her distance from the earth, and the magnitude of her phasis, that is, the proportion of her illuminated surface which is turned towards us. When her phasis is largest, resembling a full moon, she is so distant from us, that even were she not obscured by the Sun's rays, she would not be a very brilliant object; on the other hand, when she is nearest to us, we look for the most part upon her unenlightened side; and though her apparent diameter is then greater than that of any other planet, her crescent is so thin that the advantage gained in point of distance is lost by her narrowness of illumination. There will, however, be a point, which calculation will ascertain, where these two varying quantities will combine to produce the largest apparent illuminated area; this is not at the quadrature, or half-moon phasis, as she is then too distant, but when the crescent has attained a considerable breadth.

Jupiter is in great splendour, having been in opposition to the sun on March 12, with a diameter of 41″·6, only reduced to 40″ by April 17. His belts seem now to be becoming more distinct than they have been for some time; as usual, two, one on each side of the equator, are most conspicuous, and the southern asserts its customary pre-eminence. Their variations

will form a most interesting study, especially should a season of activity be coming on in that frequently-disturbed atmosphere. The transits of the satellites and their shadows across the planet always afford a beautiful spectacle, if the air is favourable, especially in a telescope which has power enough to show the disc of the entering or emerging satellite distinctly, and the circular form of the ink-spot which marks the place of its shadow. Sometimes more than one satellite, or more than one shadow, may be seen at the same moment, on the face of that noble planet; at others, the satellite passes away into the clear blue sky, and leaves its shadow behind it, or the shadow breaks in upon the planet's limb, to announce the distant approach of the little globe that casts it. But these are not merely beautiful phænomena—they are attended with circumstances of mystery which yet remain to be investigated. Excepting towards the limbs, where the light of the planet is less vivid, or in front of a dark belt, a satellite is usually invisible upon the face of its primary, from want of contrast; but instances from time to time occur in which the same satellite—usually III. or IV.—assumes so dark an aspect in that situation, as to be barely distinguishable from its shadow. There can be no question that this arises from spots upon the disc of the satellite, which the magnificent telescopes of Lassell, Secchi, and Dawes, have occasionally rendered perceptible in III., even on the background of the blue sky; but as these dark transits are of irregular recurrence, we are obliged to suppose either that these little moons have atmospheres subject to extraordinary variation, or that they have rotations upon their axes much more rapid than their revolutions round their primary—each alternative inferring a constitution totally dissimilar to that of our own satellite. These dark transits were noticed from a very early period—I believe 1666; Maraldi saw IV. pass as a black spot in 1707; Schröter probably observed them under the mistaken idea that they were spots on the disc, in 1785 and 1786; he and Harding recognized their true nature in 1796; about this time Sir W. Herschel paid much attention to these objects, and suspected that their forms might not be spherical (which has since been actually shown in the case of III., by the telescopes of Lassell and Secchi); but, strange to say, he never alludes to these darkened transits—an omission which, on the part of so accurate an observer, seems to imply that none of them had taken place under his notice. Beer and Mädler too have made no mention of them, though it can hardly be supposed that they were ignorant of former observations. But of late years they have attracted much attention, and the following description by the American astronomer Bond will be the more welcome, as few of our readers are likely

to possess the means of witnessing the minuter details for themselves:—"1848, Jan. 28.—The 3rd satellite itself was seen with the great refractor" (of nearly fifteen inches aperture) "under very beautiful definition, as a black spot between the two shadows" (of I. and III.), "and not to be distinguished from them except by the place it occupied. It was smaller than its shadow in the proportion of 3 to 5, not duskish simply, but quite black like the shadows;" and under March 18th, he thus records a similar transit of the same satellite:—"At the first internal contact the satellite was distinctly seen on the disc, *brighter* than *Jupiter*, though it had entered on a bright channel, south of one of the great equatorial belts; twenty minutes after, it had become nearly of the same brightness with the planet, so as to be barely perceptible, yet still whiter than the surrounding surface. While watching it with close attention, a minute dark speck suddenly made its appearance in the place of the satellite, increasing very rapidly till it occupied a space of about one second of arc in diameter, quite black, and nearly round, though an irregularity of shape was suspected. Remaining thus for about two hours, the darkness gradually lost its intensity, and quite disappeared before the satellite left the disc." The change thus described is of course due to the rapid diminution of Jupiter's light towards the edges of the disc; but it is strange that the eye is so little sensible of that decrease in any other way, though its amount must be extremely great, before it could thus turn white to black, from the mere effect of contrast. This wonderful observation, for such it really is, and will the more appear so, the more it is studied, tends greatly, it must be owned, to shake our confidence in the discriminating power of the eye. Dawes, from the perfection of whose telescopic vision there can be no appeal, informs us that the 2nd satellite is never thus shaded, that I. is sometimes grey, III. darker by many shades, and IV. darkest of all.

Another marvellous peculiarity, mentioned by several observers, is thus described by Lassell in the *Monthly Notices* of the Royal Astronomical Society, under the date of February 28th, 1850. "12h. 11m. The shadow and satellite" (IV.) "being now equally distant from the limb, the greater size of the shadow is most obvious; indeed, it appears to be twice as great in diameter." It is difficult to conceive any mode of accounting for this, unless we could suppose the satellite to be encompassed with an atmosphere possessed of refractive power in the opposite direction to every substance or medium within the compass of our knowledge; that it was no illusion is rendered probable by the fact that the irradiation, or spreading out of light, which is inseparable from telescopic vision, would have produced exactly the contrary effect, expanding the apparent

diameter of the satellite on the dark ground of the sky, and diminishing that of the shadow on the luminous face of the planet. We have at present no means of interpreting this mystery. As the more obvious features of these curious and beautiful phænomena may be perceived with a very moderate aperture—I have myself seen the "ink-spots" well with only three inches—we shall give a list of all that are visible at convenient hours during the present month; including May 1st, for the sake of readers whom our information might not otherwise reach in time.

April 1st. I. is on the disc from 8h. 10m. to 10h. 27m. followed (as always after the planet's opposition) by its shadow. 2nd, II. emerges at 7h. 41m.; the shadow continuing in sight an hour longer. 8th, I. is in transit from 9h. 57m. to 12h. 13m. 9th, shadow of II. enters at 8h. 27m., the satellite being already on the disc; egress of II. 9h. 57m.; of shadow, 11h. 15m. IV. having crossed already, and being to the left of the planet in an inverting eyepiece, its shadow comes on separately at 9h. 28m. and leaves at 12h. 34m. 15th, I. enters at 11h. 43m., followed by the shadow at 12h. 28m. 16th, II. enters at 9h. 28m., its shadow at 11h. 1m.; it goes off at 12h. 15m., the shadow at 13h. 49m. 17th, I. leaves the disc at 8h. 26m.; its shadow at 9h. 14m. 22nd, I. enters at 13h. 30m., the shadow at 14h. 23m. 23rd, II. enters at 11h. 45m., the shadow at 13h. 36m. 24th, I. egress at 10h. 14m., ditto of shadow at 11h. 9m. 27th, III. being already off the planet to the left, the shadow enters at 8h. 13m., and departs at 11h. 28m. May 1st, I. is on the disc from 9h. 46m. till 12h. 3m.; the shadow enters at 10h. 47m.

It will be seen that there is no chance of a thoroughly dark transit this month, as III. and IV. will not be on the disc; but, weather permitting, we must not miss the interesting sight on the 9th, when the shadows of II. and IV. will both be visible at once for nearly two hours; and we shall not fail to remark, if we have a sufficiently powerful instrument, the contrast in the size of the spots, as well as the difference in their velocities, and distances from the bodies which cast them.

The presentation of Saturn's ring as a slender but conspicuous line, will be very beautiful this month. The Sun and Earth are at present both on the same side of it; were they both at the same elevation above its plane, it would, of course, exactly conceal its own shadow; but as the the Earth is slightly the more elevated, we see a very little under its inner edge, as compared with the Sun (the south side being the one visible), and it is possible that in fine telescopes a very narrow black line, the edge of the shadow, may cross the centre of the ball. The belts on each side of the equator seem to be faint this

season. A three and three-quarter inch object-glass, if good, will show the five old satellites every clear night, unless any of them happen to be before or behind the planet, or in its shadow. The shadow of Titan, the largest statellite, was once seen crossing the disc by Sir W. Herschel in 1789. Gruithuisen also says he saw it in 1833 with a four and a-quarter inch object-glass; which is no doubt possible, as it may have a diameter of 0″·75; but his assertion that he saw the two innermost and most minute satellites at the same time, gives an imaginary character to the recital.

THE GENUS CEPHALOSIPHON.

BY ANDREW PRITCHARD.

It may interest naturalists engaged in these studies to learn the source from which I obtained the character of the genus *Cephalosiphon*, referred to in a paper by Mr. Gosse, "On a Rotifer new to Britain" (*Intellectual Observer*, p. 49). Allow me to premise that in preparing the fourth edition of my work on Infusoria, one part of my self-imposed task was the search through foreign transactions and journals for new forms, having determined to introduce every published genus and species. This task became laborious, as no public library contains the whole of the foreign works on this subject; nay, even a complete set of the proceedings of the Berlin Academy is not to be found in any one of them. After making these searches, a copy of my notes on the Rotifers was forwarded to Professor Williamson, who inserted the *Cephalosiphon* in his revise, for it is not in his MS., nor in my edition of 1852. On looking over my notes, I find that referred to was taken from the *Proceedings of the Berlin Academy for* 1853, p. 193, in the library of the College of Surgeons, and is as follows:—

"Cephalosiphon (new genus, *Ehrenberg*), Horn-Röschen. Family, *Flosculariorum;* organon rotatorium bilobum; ocelli duo; Vagina s. lorica singula; Cornicula duo frontalia siphonem includentia.

"*C. Limnias*, E. Vaginulis membranaceis annulatis, 1″·6′ 1″·5′. In ceratophyllo: Berolini."

In conclusion, permit me to express the pleasure I feel that the labour of collecting the characters of so many exotic forms has not been thrown away; also for Mr. Slack's valuable researches, by which we learn the rotatorial animalcules have a wide range of geographical distribution.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

ROYAL SOCIETY.—*February* 6.

ON THE MOTION OF SMALL PORTIONS OF CAMPHOR WHEN THROWN ON THE SURFACE OF PURE WATER.—Mr. Tomlinson communicated a paper descriptive of the very elaborate series of experiments he had made to investigate this curious subject. The following is an abstract of the conclusions he had deduced from his investigations:—That to succeed in the production of these movements the camphor must be thrown on the surface of clean water in a perfectly clean vessel. That these phenomena may be also produced by certain salts, and other substances that diffuse readily over the surface of water. Thus the motions of camphor may be imitated by placing on water floating rafts of talc, tinfoil, paper, etc., smeared with or containing volatile oils, or any volatile liquid, such as ether, alcohol, chloroform, etc., provided there be a communication between such liquid and the water. The camphor or other volatile substance, being slightly soluble in water, spreads a film over the surface of the water the moment that it comes in contact with it. The dimensions and form of this film evidently depend on those of the piece of camphor operated on, and in general the film separates more easily from broken surfaces and angles than from a smooth surface, as the broken surface of a crystal is more soluble than the natural surface. These films being constantly detached from the camphor so long as it is in contact with the water, displace each other, the preceding film being conveyed away by the adhesion of the water in radial lines, which produce motion by reaction on the fragments of camphor, causing them to rotate in the same manner as a Barker's mill. These jets or films of camphor can be rendered visible by various means, as by fixing the camphor in water, and dusting the surface lightly with lycopodium powder, when a series of currents produced by the films will be made visible. The motions of the fragments of camphor on water are greatly influenced and complicated by their mutual attraction, and by the attraction of the sides of the vessel. The film of camphor diffused over the surface of the water is very volatile, disappearing as fast as it is formed, chiefly into the air, only a very small portion being retained by the water. Hence camphor wastes away much more quickly at the surface of the water than in water alone, or in air alone, because at the surface the film is being constantly formed at the expense of the camphor, and is spread out to the united action of air and water. Whatever interferes with evaporation lowers or arrests the motions of the camphor and the allied phenomena; so, on the contrary, whatever promotes evaporation exalts these phenomena—effects which are displayed with great energy on a bright and sunny day, are produced either sluggishly or not at all on a wet, dull, or foggy one. A fixed oil forming a

film on water will displace the camphor-film, and so permanently arrest the motions of the camphor; but a volatile oil will only arrest the motions while it is present and undergoing evaporation. The motions of camphor on the surface of water are increased by the action of the vapour of benzole and some other volatile substances, such vapours condensing in the liquid form on the camphor, and being then diffused by the adhesion of the water.

ROYAL SOCIETY, *February* 20.

On the Dicyodont Reptilia brought from South Africa, by His Royal Highness Prince Alfred.—A communication was made by Professor R. Owen, describing some fossil remains obtained by His Royal Highness Prince Alfred, during his recent journey in South Africa. They belong to two genera of Dicyodont Reptilia, the first being an unusually perfect specimen of the skull of a species of *Ptychognathus*, which the author proposes to name *P. Alfredi*. The second specimen is the skull of the largest known species *Dicyodon trigriceps*. This skull is remarkable as exemplifying the near equality in size of this extinct two-tusked reptile of South Africa with the existing walrus. The pelvis of the Dicyodon is singularly massive, and offers many points of approach to the mammalian type, which is remarkable when taken into connection with the mammalian tusks in the skull.

GEOLOGICAL SOCIETY.—*February* 26.

On the Ice-worn Rocks of Scotland, by T. F. Jamieson, F.G.S.—The author, first referring to the eroded surface of the rocks beneath the Drift-bed in Scotland, proceeded to show that the action of ice, and not that of torrents, could produce such markings as he had observed in the bed of a mountain-stream in Argyllshire, down which had poured the torrent caused by the bursting of the reservoirs of the Crinan Canal. He then advanced reasons for considering that the erosion of the rocks in Scotland was due chiefly to land-ice, and not to water-borne ice, bringing forward remarkable instances of ice-action on the glens and on the hill-sides at Loch Treig and Glen Spean, where moraines, blocs perchés, striæ, roches moutonnées, and boulders lifted above the parent-rocks, indicate a northern direction for the great ice-stream from Loch-Treig to the Spean, and then an eastern course on one hand up Loch Laggan, and a western, on the other, down the Spean. Up Glen Roy the ice had apparently passed north-eastwardly, over the watershed, towards the Spey. In Knapdale, Argyllshire, similar evidence is obtained of a great ice-stream passing over hill and dale, here falling into the Sound of Jura. The author referred to Rink's and Sutherland's observations on the continental ice of Greenland, as affording a probable solution of these phenomena; and, objecting to the hypothesis either of floating ice and of debacles being sufficient to account for the con-

ditions observed, he thought that land-ice, moving from central plateaux downwards and outwards, has effected the extensive erosions referred to, both in Scotland and other northern regions, at a time when the land was at a much higher level than at present. This must have been followed by a deep submergence, to account for the stratified and shell-bearing drift-beds.

ZOOLOGICAL SOCIETY.—*February* 28.

Incubation of the Python.—Mr. Bartlett exhibited a young python, taken on the 15th day of incubation from an egg which had been detached from the general mass; the animal was about 6 inches in length, the eyes were very distinctly visible; estimating the development as equal to that of a chick on its seventh day, Mr. Bartlett calculated the full period of incubation as being seven to eight weeks. In connection with Mr. Negretti, who had constructed some exceedingly delicate thermometers for the purpose, Mr. Bartlett had made a number of observations on the temperature of the incubating python.

The temperature of the air in the room was maintained at about 55° Fahr., that of the water-bath heating the sand on which the animals rested was 74°; on the 12th of February the temperature of the incubating female on the surface of the body was 73°, that of male in same den being 70°·2, whilst between the coils the female was 81°·6, the male only 74°·8. On the 23rd of February, the surface of the body of the female was 75°·4, that of the male 71°·8. Whilst between the coils the female was 83°·2, the male 74°. Observations made subsequently to this date showed a still greater difference of temperature between the two sexes, amounting on March 2nd to 20°, the female being 96°, the male only 76° between the coils. Some days after this, the female left the eggs and bathed in the tank placed in the den, changing her skin at the same time. After that her temperature fell considerably, and she did not for some days incubate the eggs with the same closeness as before. On March 16th the temperature was again carefully tested, the atmosphere of the den was 66°. That of the male on the surface of the body 72°·4, between the coils 77°·6; whilst the temperature of the incubating female was 77°·6 on the surface, and 86° between the coils; but as an outer coil was tested, it is probably that a higher temperature may exist between the innermost coils. On the 25th of March, the eggs were examined as far as practicable. Many of them promise to be productive; others have collapsed. The female python is now only 10° hotter than the male, instead of 20°, as formerly. She has now been incubating nine weeks.

On the Red Corpuscles of the Blood of Vertebrata, by Professor Gulliver, F.R.S.—There have been two parties differing essentially in their conclusions as to the structure of the corpuscles of the blood, both correct as far as they went. The first party, of which Hewson was the representative, insisted that the red corpuscle

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is a vesicle inclosing a nucleus; the second party, of which Dr. Hodgkin and Mr. Lister were the chiefs, were equally certain that Hewson was wrong, and that the red corpuscle has no nucleus. Professor Gulliver showed, as the result of his researches from 1839-42, that the red corpuscle of mammalia is destitute of any nucleus, while the red corpuscle of oviparous vertebrata, on the other hand, always has a nucleus. Hewson having drawn his description from the corpuscles of fish or fowls was quite right so far; and Hodgkin and Lister having examined only the corpuscles of man were equally correct in the same restricted sense. Thus Mr. Gulliver's observations not only completely cleared up the long existing discrepancies between former observers, but fairly settled "this vexed question of a nucleus," as it had so long been called.

Further, he asserted that the result of his observations clearly was, that the most important, because the most universal and fundamental, difference between the two great divisions of the vertebrate sub-kingdom, is the presence or absence of this nucleus; so that any one possessing a good microscope could at once plainly see the difference between the red corpuscles of these two divisions of vertebrata. It was also shown that this character is perfectly good from before birth, and throughout life, and in every age and sex, which was more than can be said of any other single diagnostic, whatever may be its importance. Hence Mr. Gulliver proposed to define the two divisions as follows:—

1. Mammalia, animals whose red corpuscles of the blood are destitute of nuclei.

2. Oviparous Vertebrata, animals whose red corpuscles of the blood contain nuclei.

He said there was no known exception to the accuracy of these definitions, and that he had proved in 1839 that even the singular oval corpuscles in the blood of *Camelidæ* were in size and structure truly mammalian.

The largest corpuscles among mammalia were shown to be those of the whale, the great ant-eater, and the elephant; and the smallest, as originally described by Mr. Gulliver, those of the musk deer. The largest corpuscles in the vertebrata are those of naked reptiles, and the most regular or least variable those of birds.

Thus the microscope is fairly enlisted into the service of systematic zoology. The subject was followed out in detail throughout the different classes and orders; and so plainly, that an observer might, by remarking the structure of the blood corpuscle, arrive immediately at results which, without the aid of the microscope would have formerly puzzled the most eminent comparative anatomists. One minutest drop of the blood, for example, of the duck-billed creature, *Ornithorynchus paradoxus*, would have shown it to belong to the mammalia, and this even in the most immature specimen!

The following suggestions have been made by Professor Gulliver. Reverting to his discovery of the microscopic structure of the red corpuscles of the blood being a better diagnostic than any hitherto offered between the two great subdivisions of the vertebrata, he now suggests that the intimate structure of the latex may afford good bota-

nical characters. The milkiness or opacity of the latex may be due to equal sized particles of extreme minuteness, like the molecular base of the chyle of mammalia; or to larger, unequal sized, oil-like globules. There may also be starch-cells in the juice, as in *Euphorbiaceæ*. The limpid fluid in which the microscopic objects of the milky juice swim he calls Liquor Laticis. It is spontaneously coagulable at the temperature of the air, and is remarkably coagulated by water. The whole subject is one that may be easily examined by micrographers in the country, and the season is approaching for this interesting pursuit.

CHEMICAL SOCIETY.—*March* 1.

Destruction of Oak Timber in Sea Water by contact with Iron.—Mr. Crace Calvert called attention to the destructive action of iron plates and bolts on oak timber when submerged in sea water; the oak at the point of contact becomes dark in colour, softened, and partially disorganized. This change appears to be dependent on the presence of tannin, as teak and mahogany are not affected in the same manner as oak. The probable result of the action will be, that ships of oak plated with iron, after the manner of the "Warrior" and other vessels recently constructed, will become unserviceable in the course of a very few years. It is found that if the iron is protected by a coating of zinc—or, as it is termed, is galvanized—the action is prevented, and the oak timber does not change in colour or solidity. This mode of protection is even applicable to the iron bolts used in ship-building, as it is found that so close and complete is the adhesion of the two metals, that the zinc is not stripped off when the bolts are driven into the timber.

ETHNOLOGICAL SOCIETY.—*March* 4.

On the Shell Mounds of the Malay Peninsula.—Mr. G. W. Earl described the singular shell mounds existing in the province of Wellesley, near the Mudah River. They are about five or six miles from the sea, being situated on sand ridges that appeared formerly to bound the narrow estuaries communicating with the ocean. The mounds, which are entirely composed of cockle-shells, are about 18 to 20 feet in height, and recently have been largely employed by the Chinese immigrants as a source of lime. The antiquity of the mounds must be very great, as shown by the fact that the shells were partly cemented together by crystallized carbonate of lime, the result of the very slow action of atmospheric and aqueous influences. At the bottom of one mound, which contained 20,000 tons of shells, a human pelvis was found, and other remains and stone implements have been obtained from the Chinese lime-burners. The formation of these mounds was attributed by Mr. Earl to the Semangs, who are described as a diminutive negro race that are now sparsely scattered over the surrounding country, but who were evidently very numerous and widely spread formerly.

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ROYAL GEOGRAPHICAL SOCIETY.—*March* 10.

CAMBODIA.—At the present moment, when the French appear likely to be about to establish their empire permanently in Cochin-China, any information about the little-known countries of Farther India must be regarded not only as valuable contributions to geographical science, but as worthy of general interest. The province of Cambodia, lying between Siam and Assam, was, in the end of last century, the subject of constant wars between the peoples of those kingdoms. In 1860 the French landed, and in 1861 took Saigon. They have since been endeavouring to establish a footing in Cochin-China.

M. Mouhot, a French traveller, has recently passed through Cambodia, up the Me-Kong, near to the frontier of Laos, and visited the savage and independent tribes which live between these two countries and Cochin-China. These Steings he considers to be the aboriginal inhabitants of the peninsula. During his journey, M. Mouhot discovered two active volcanoes on the north shores of the Gulf of Siam, and everywhere in the mountains to the north the evidences of volcanic action. He refers to the products of the country, which are cotton, iron, coal, gold, silver, and copper, besides valuable woods. In an extension of his journey across the lake of Touli-Sap, and through the provinces of Ongeor and Battambong, M. Mouhot discovered and examined some splendid ruins and a monument, the temple of Ongeor the Great. He has sent home drawings and descriptions of these ruins. Many of the buildings were constructed of large stones, elaborately carved and covered with designs of imaginary animals, as well as of beasts of burden. These temples were found in a district completely embedded in the forest, and in such a state of ruin that trees were found growing upon the roofs. The inscriptions, from their antiquity, were not intelligible to the natives; yet they so nearly resemble the Siamese character, that it is probable they will soon be deciphered.

NOTES AND MEMORANDA.

INFLUENCE OF WATER ON VOLCANIC ACTION.—In a paper read before the French Academy, on "Volcanic effects corresponding with geological epochs" (*Comptes Rendus*, January 27, 1862), M. Pissis remarks that it is generally believed, in those districts of South America which are most subject to earthquakes, that these disturbances occur during the rainy season, and up to the period of drought. During twelve years of his own residence on the spot this theory has held good, and the years of most violent rain were distinguished by a greater number of earthquakes; and he adds, that if we consider that during the wet season the Andes are covered with a dense bed of snow, which is perpetually melting from contact with the soil, it will be obvious that an extensive infiltration must take place; so if there exist any fissures communicating with the interior, large quantities of water may be brought into contact with incandescent matter, and thus occasion very powerful disturbances.

COMPARATIVE FUSIBILITY OF IRON.—MM. Minary and Résal state that the fusibility of iron augments with the proportion of oxygen which it contains: thus, in placing side by side, in a blast furnace, two crucibles containing iron shavings of the best quality, but adding to the second a certain proportion of oxide of iron

after exposure to a hot blast (*coup de feu*), the fragments in the first crucible preserved their original condition, except that they were slightly welded together, while those in the second were fused into a lamellated button.—*Comptes Rendus.*

Volcanic Phenomenon in Manilla.—A letter to Dr. Hooke, communicated to the Geological Society, states that on the 1st of May, 1861, a portion of the river Pasig was subject to a violent commotion, which continued for four hours. For the space of a quarter of a mile the water was covered with air-bubbles and foam, the temperature being raised to 100° and 105°, other parts of the river being at 80°. Mounds of mud were raised several feet above the surface of the water, and gave out an offensive odour. At the expiration of the time mentioned the mounds disappeared, and the river resumed its ordinary aspect.

The Divining Rod.—M. Chanoit, director of the hydraulic works of the Paris and Lyons Railway, announces that he has in service a young man so well practised in discovering springs or masses of water with the divining rod, that he would undertake that if he were taken blindfold through Paris, he would indicate the various water channels and their relative importance. He has such confidence in his hydrologist, that he begs the Academy to appoint a commission to witness his performances.—*Cosmos.*

Physiology of the Nerves of Insects.—M. Yersin has communicated to the French Academy the results of observations on the field-cricket (*Comptes Rendus*, February 10th, 1862). He finds the power of co-ordinating movements not affected by cutting through both cords of the ganglionic chain. On the contrary, the motions became abnormal every time a single cord was severed at any point anterior to the ganglion of the meta-thorax, and likewise when two or more divisions were made, each of one cord, between different ganglia, one at least of the sections being anterior to the meta-thorax. He regards the cephalic and thoracic ganglia as together presiding over the co-ordination of locomotive movements, so that it is impossible to assign this function to any one ganglion, to the exclusion of the others. In this he traces a relation to the cerebellum of vertebrate animals, and he remarks that it is probable that it is in the "reunion of ganglia that we must look for an analogy to the brain of the vertebrata."

Electrical Phenomena of Vesuvius.—M. L. Palmieri first observed the flashes of volcanic lightning at a distance of a few hundred yards from the new crater at Torre del Greco. They always originated in large "globes of smoke," and were followed by explosions like pistol discharges. Afterwards from the Observatory he noticed similar flashes between the smoke and cinder masses and the aqueous vapour above them, but very seldom between the "globe of smoke" and the earth beneath it. At each violent projection of smoke, his instruments indicated a strong tension of positive electricity, and when this reached a certain force, thunder and lightning occurred. If the discharge occurred in the direction of the zenith of the Observatory, a sudden increase of positive electrical tension was produced; while, if the discharge was directed towards the earth, or to a distant region in the air, the tension became negative. The vapour which moved towards the Observatory, if free from cinders, was strongly positive; but the cinders which fell when the smoke of a superior current deviated from the zenith were negative.

M. Pasteur on Fermentation.—We find in the *Comptes Rendus* of the 10th of February a further account of M. Pasteur's laborious researches on fermentation, of which the following are the chief particulars. He began his investigations by experimenting on the *Mycoderma vini* or *cervisiæ*, popularly known as the "mother of wine." Causing this plant to develop in various alcoholic liquids in contact with air, he never obtained acetic acid; and if he introduced a small portion of that acid, it usually disappeared. When the *Mycoderma aceti*, or vinegar-plant, was grown in alcoholic liquids, acetic acid was always formed, with the intermediate production of small quantities of aldehyd.* In both cases

* "The alcohols may all be regarded as compound oxides of hydrogen, and of a peculiar hydro-carbon. . . . The alcohols, by imperfect oxidation, furnish *aldehyds;* and these bodies, by the further absorption of oxygen, yield acids."—*Miller's Chemistry*, vol. iii. p. 119.

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the chemical phenomena and the life of the plants were clearly correlative. When the experiments were performed in close vessels containing besides the liquid a known quantity of air, it was ascertained that the vinegar-plant took oxygen from the air, and therewith converted the alcohol into acetic acid; and that the mycoderm of wine took oxygen from the air, and converted the alcohol into water and carbonic acid. It was likewise ascertained that if the alcohol was removed, and the vinegar-plant grown in an acetic liquid, the acid was transformed into water and carbonic acid. With the mycoderm of wine the effect was the same, especially if there was a little alcohol in the liquid. From these facts M. Pasteur concludes that the wine and vinegar plants behave in the same manner, and that there are circumstances in which their action is exalted, that is to say, that the plant, instead of taking from the air two, or four, molecules of oxygen to combine with one molecule of alcohol, and thus produce aldehyd or acetic acid, takes eight, or twelve, molecules of oxygen, and by their aid completely transforms the alcohol and the acetic acid into water and carbonic acid. The vinegar-plant does not produce acetification when it is submerged. This was ascertained by noting the degree of acidity of a liquid in which a growing plant floated. The plant was made to sink by glass rods, and the acetification was arrested. Following his investigations, M. Pasteur arrives at the conviction that the well-known process of manufacturing vinegar by allowing a suitable liquid to trickle over wood twigs or shavings, is not, as was supposed, a purely chemical process, but dependent upon the formation of a pellicle of the vinegar-plant. The important paper from which we have condensed these observations concludes in these words:—"If the mycoderms possessed solely the property of acting as agents for the combustion of alcohol and acetic acid, their performance would be well worth attention; but I recognize in their functions a generality of action which opens a field for new researches in physiology and organic chemistry. In fact, the mycoderms are able to bring about the combustion of a great number of organic substances, such as sugars, organic acids, various alcohols, and albuminoid matters, giving rise in some cases to intermediate compounds, of which I have recognized a few. I may add that the property which we are discussing exists in various degrees among the mueidines, and I believe also among the smallest of the infusoria. I have observed that by the development of a mueidine, it is possible to transform into carbonic acid and water considerable quantities of sugar, so that scarcely any of that substance shall be left in a solution. If microscopic beings disappeared from our globe, its surface would be encumbered with dead organic matter and carcases of all kinds, animal and vegetable. It is they who chiefly give to oxygen its combustion-producing qualities. Without them life would be impossible, for the work of death would be incomplete. After death life reappears under another form, and with new properties. The germs, everywhere disseminated, of microscopic beings commence their evolutions, and by their aid oxygen is combined in enormous masses with the organic substances, and their combustion gradually rendered complete. If I may be permitted to characterize briefly another point of view to which we have been conducted, I would say that we obscure the existence of organized cellules endowed with a property of completely burning organic masses with considerable evolution of heat, or of carrying their oxidization to a variable extent. This is a faithful image of the respiration and combustion which take place in the pulmonary cells through the circulation of the blood, whose globules seek oxygen from the air, in order that they may burn in various degrees the different principles of the human economy."

ROMAN RING-KEYS.—Some of the Roman keys attached to rings so as to be worn on the finger, and which are well known to antiquaries, were recently found at Water Newton in digging for gravel, close to the road from Stamford to Peterborough. Associated with them were cinerary urns and lachrymatories. The rings were of brass and bronze, and of the size used by the Roman ladies, who were accustomed to carry their casket keys in this manner.

NEW THEORY OF COMETS.—Mr. Benjamin Marsh has published some interesting facts and opinions concerning these curious bodies in the *American Journal of Science and Arts*. He attributes the peculiar character of cometary matter

to the extreme and violent changes which it undergoes in its rotation round the sun. Halley's comet, for example, at one time approaches the sun to within 56 millions of miles, and then recedes to the enormous distance of 3370 millions of miles. At the time of its perihelion, or least distance, it passes through one heliocentric degree of its orbit in 15·7 hours, and receives in a given time 3600 times as much heat as when it reaches its aphelion, or greatest distance, in which position its motion is so slow that 6½ years are required for its passage through one heliocentric degree. Thus it will be seen that comets with eccentric orbits are subject to violent changes of temperature and velocity, which do not affect planets whose orbits approximate more closely to the circular form, and from this circumstance a greater electrical disturbance and excitation may possibly be produced. Mr. Marsh gives a table of remarkable comets, showing that those which have exhibited the greatest splendour have been distinguished by extreme eccentricity, while comets of small eccentricity have been inconspicuous. From this law it follows that brilliant comets have long periods; and he tells us that, with the exception of Halley's comet, which performs its journey in seventy-six years, no other first-class comet has a shorter period than one measured by centuries. Mr. Marsh likens the tails of comets to auroral streamers, and considers that their envelopes resemble the electrical discharges in Mr. Gassiot's vacuum tubes, the luminous character being derived from the solid particles which the electrical current transports from the nucleus, just as similar particles are carried off from the electrodes in a voltaic discharge.

Heliography.—M. Chevreul, in presenting to the French Academy some fresh researches of M. Niepce de St. Victor, explained two remarkable facts: "the first is, that the image produced by the sun is direct, and not inverted, like those obtained by ordinary methods; the second is, that the light whitens the parts which it strikes, through a special action of the dextrine and chloride of lead varnish, while without this varnish it would impress a violet tint on the chloride of silver of the daguerreotype plate—a remarkable result, since M. Niepce has observed that the shadows of an engraving are reproduced in black on plates prepared with his varnish. The colours of the image are not produced simultaneously; for example, the yellow appears before the green, and when this latter is manifested the yellow is weakened, if not effaced. Does it not follow from this, that the way to reproduce the colours with fidelity would be by the use of screens, so arranged as to cover the parts where the colours are first exhibited, so as to give more time to other colours which require it?"

M. Flourens on Respiration.—In a warm-blooded vertebrate animal, respiratory movements are instantly arrested if the medulla oblongata is divided "in the centre of the V of the gray matter," and the creature dies immediately. In a frog, pulmonary respiration ceases on making a similar division,* but the animal continues to live through its cutaneous respiration. The respiration of a fish ceases if the medulla oblongata is divided by a section which passes just behind the cerebellum, and the animal dies more or less quickly, according to the species. M. Flourens observes—"The lobes, or cerebral hemispheres, minister to intelligence, and that only; the cerebellum is devoted to the co-ordination of the movements of locomotion, and there is a point in the medulla oblongata which presides over the movements of respiration."

Connection between Human and Cattle Disorders.—Professor Gamgee, in an article on the "Health of Stock," in the *Edinburgh Veterinary Review*, states that he has noticed a remarkable connection between diseases in man and in the lower animals; he believes many of the former may be traced to unwholesome food. The same authority affirms that on the average 33½ per cent. of the cows kept in any large town die annually of disease; and he asks, "If our sanitary reformers are alarmed at a mortality of two hundred persons in ten thousand, what will they say to more than sixteen times that mortality amongst our poor cows?"

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* The "nœud vital" of the frog exists in "l'espèce de pont que forme sur le plancher du quatrième ventricule, le cervelet, d'ailleurs très-petit, de ces animaux."—*Comptes Rendus*, p. 315, No. 6, 1862.